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METHODS FOR VISUAL TESTING IN SCHOOLS

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The obvious, but at present unattainable, ideal is for every school child to have a yearly ocular examination by a competent opthalmologist. As this is impracticable, some type of screening test must be carried out in the schools, either by lay persons or by the attending general physician. An attempt has been made to evaluate some of the present methods used in the schools by a comparison of the results of following charts and tests:

1. The Snellen chart
2. The Betts test
   (*a*) As interpreted in Betts's textbook on reading difficulties, published in 1936
   (*b*) As interpreted by the department of child welfare, independent school district of Davenport, Iowa
3. A group of ophthalmic tests, consisting of the Snellen chart at 6 meters, the Duane screen test at 6 meters and 33 cm. and the Worth four dot test at 6 meters and 33 centimeters

   (This group of tests will hereafter be referred to as my group of tests, for lack of a better name.)

DESCRIPTION OF TESTS AND PROCEDURES

The Snellen chart was used under uniform conditions of lighting of approximately 20 footcandles. Vision of 20/30 or better was considered as passing.

The Betts tests, which, for the benefit of those not familiar with them, consist of a series of twelve stereoscopic slides used in a calibrated stereoscope, are designed to examine the following functions: (1) gross fusion, (2) distance fusion, (3) visual acuity of both eyes and of each eye separately, (4) vertical muscle imbalance, (5) depth perception, (6) lateral muscle imbalance, (7) fusion at the reading distance and (8) sharpness of image (the latter test being one based on the principle of the astigmatic dial).

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These tests were used and the results graded according to Betts's instructions as described in the 1936 edition of his textbook on reading difficulties.

The same results were then graded according to the method used by the department of child welfare of Davenport, Iowa, which is a percentage system, 5 to 10 per cent being deducted for each failure with an individual test and 75 per cent being considered a passing grade.

For my group of tests the Snellen chart was used as previously described, vision of 20/30 or better being required for passing. Fusion of the Worth four dot test at 6 meters and 33 cm. was required. In both the distance and the near test, each dot subtends a visual angle of 13.3 minutes and the horizontal and vertical distance between dots an angle of 40 minutes. With the use of the Duane screen tests at 6 meters, any consistent movement of the eyes, in or out, on alternate covering was considered failure to pass. With the screen test at the reading distance, any outward movement of the eyes was considered failure, and any movement of the eyes inward not neutralized by a 5 diopter prism, base in, was considered failure. Visual acuity tests at the reading distance were not included because of the usual large amount of accommodation present in children and the relative rarity of paralysis of accommodation. Fusion tests were included because of the increasing evidence that fusion and ocular dominance are important factors in reading disabilities and because they are a good check on the visual acuity and muscle balance tests.

The tests were all performed on average school children between the ages of 8 and 16. Seven hundred and forty-five examinations were performed in three different schools by three lay examiners, untrained except for two to three hours individual instruction in the use of the various tests. The tests were performed on all the individual children at the same session. The order in which they were given was alternated so as to exclude fatigue phenomena. It was understood that none of these tests were to be considered in any sense diagnostic but were merely methods of determining which children should be referred to an ophthalmologist for a complete examination. The results (in percentage) obtained with these tests were as follows:

No. of Children Examined..... 745

Test	Passed %	Failed %
Snellen test	89.7	10.3
Betts test (the Betts method of grading)	17.4	82.6
Betts test (the Davenport, Iowa, method of grading)	58.4	41.6
My group of tests	55.4	44.6

The marked discrepancy in results can at once be noted. It would seem obvious that any test which finds 82 per cent of school children

with defective vision is far too discriminating and defeats its own purpose. If 82 per cent of school children have defective vision, it would be far more sensible to refer all children to an ophthalmologist in the first place and eliminate a screening test. The figures further suggest that the Snellen test used alone is missing a considerable number of muscular and fusional difficulties.

A comparison of the results obtained with the Snellen test with those obtained with the Betts visual acuity test follow:

No. of Children Examined..... 745

Results of	Failed Betts Test	Failed Snellen Test
Tests Agreed	Passed Snellen Test	Passed Betts Test
90.5%	8.0%	1.5%

The correlation of the results of these tests is fairly good. It would seem that the Betts test was slightly more discriminating.

A comparison of the results of the fusion tests with those of the four dot test revealed:

No. of Children Examined..... 745

Results of	Failed Betts Test	Failed Four Dot Test
Tests Agreed	Passed Four Dot Test	Passed Betts Test
53.5%	35.3%	11.1%

The correlation of the results of these tests is not good, and the Betts test again seems to show the greater percentage of failures.

A comparison of the results of the muscle balance tests with those of the Betts test (745 children) further shows:

Results of	Failed Betts Test	Failed Duane Test
Tests Agreed	Passed Duane Test	Passed Betts Test
68.9%	26.4%	4.5%

Again the same comment can be made concerning these tests as was made concerning the fusion tests.

The reason for the lack of correlation of the results of the fusion and muscle balance tests, in my opinion, is that the introduction of a stereoscope produces artificial factors which inhibit normal binocular vision. Any one who has spent any time attempting to fuse stereoscopic roentgen plates will testify that it is not always easy. Further, a psychic factor enters, in that the object viewed is actually only a few centimeters from the eyes, although due to the decentered lenses of the stereoscope optically the object is at infinity.

A further criticism of the Betts test is that the time consumed in examining the individual patient is almost double that with my group of tests. The correlation between the results of the latter group of tests and the Davenport method of grading the results of the Betts

test was close. Here, however, in addition to doing the Betts tests, which in themselves are time consuming, one has to grade the results of each test according to a relatively complicated percentage system.

SUMMARY AND CONCLUSIONS

Since it seems impracticable to have all children examined by an ophthalmologist, the ideal school visual test would appear to be one which detects the majority of ocular defects which might have a bearing on health or educational problems. According to the figures, it is apparent that the Snellen chart used alone misses a certain percentage of muscular and fusional difficulties. It is further apparent, I believe, that the Betts test has two major faults in its present state of development: First, it is definitely too discriminating a test. To repeat, if over 80 per cent of children have ocular defects, the sensible procedure would be to have all children thoroughly examined without a needless preliminary screening examination. Second, the figures obtained from the Betts tests are not well correlated with those obtained from the use of more generally accepted ophthalmic tests. If visual screening tests, introducing different principles than those used by the large majority of ophthalmic physicians, are to be used in the nation's school system, the ophthalmologic profession has the right to expect that the findings will fairly well agree with the more commonly used procedures.

My group of tests would seem to strike a mean between the other two tests considered in this paper. The tabulated results would seem to warrant the conclusion that the tests in present use are either inadequate or overzealous and that a further effort toward the development of standard visual efficiency tests to be used in the nation's schools should be made.

[The discussion on this article, which was received just as the issue was going to press, will be found on page 427 of this issue.]

SITE OF DISTURBANCE IN ADIE'S SYNDROME

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Adie's syndrome has frequently been reported from Germany and England but rarely from this country. The entity consists essentially of tonic pupillary reactions with or without absence of tendon reflexes. As will be seen later, it manifests itself in several forms.

The so-called myotonic pupil was first described almost simultaneously in 1902 by Strasburger [1] and Saenger,[2] though their observations were made independently. This type of pupillary reaction, as described by these authors, consisted of very slow contraction to light and in convergence and accommodation, followed by an even slower dilation on removing the stimuli. The amplitude of the convergence reaction was normal or even excessive. The light reaction was the most sluggish, and in one of Strasburger's original cases it was absent entirely. From that time until the present, numerous articles on this pupillary disorder have appeared in the medical literature. Various names have been proposed for the phenomena, including in addition to the two already mentioned, pseudo Argyll Robertson pupil, Markus' peculiar pupil phenomena and pupillotonia. However, tonic pupil is the term most commonly accepted and will be used in this paper.

Of interest is the fact that in many cases the tonic pupil was found in patients with diminution or absence of tendon reflexes. Adie [3] in 1931 was among the first to take cognizance of this relation, reporting 6 cases of his own and pointing it out as an entity. He emphasized the importance of care in recognizing the condition and in differentiating it from tabes dorsalis with Argyll Robertson pupils. In a later article in 1932 [4] he reported 8 more cases and reviewed the literature, finding 44 cases of tonic pupils, in 9 of which absence of tendon reflexes was

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1. Strasburger, J.: Sluggishness of the Pupil to Accommodation and Convergence, Neurol. Centralbl. **21**:738-740, 1902.

2. Saenger, A.: Myotonic Pupil Movement, Neurol. Centralbl. **21**:837-839, 1902.

3. Adie, W. J.: Pseudo-Argyll-Robertson Pupils with Absent Tendon Reflexes, Brit. M. J. **1**:928-930, 1931.

4. Adie, W. J.: Complete and Incomplete Forms of the Benign Disorder Characterized by Tonic Pupils and Absent Tendon Reflexes, Brit. J. Ophth. **16**:448-461, 1932.

reported. In this paper Adie further elaborated on the syndrome and classified it. As a result of his observations, the condition is known by his name. Bramwell [5] in 1936 proposed calling it the Holmes-Adie syndrome, for at about the time of Adie's first paper Holmes [6] reported 54 cases, largely gathered from the literature, in 19 of which tendon reflexes were diminished or absent. Markus' [7] name has also been attached to the syndrome, but even before the report of his case with absence of tendon reflexes in 1906, Nonne [8] in 1902 had reported a similar case.

In his second paper Adie [4] divided the syndrome into the complete and incomplete forms. The complete form was characterized by a tonic pupillary reaction in convergence with apparent inactivity to light associated with diminution or absence of some or all tendon reflexes. The incomplete form may manifest itself by (1) tonic pupils alone, (2)

TABLE 1.—*Points of Differentiation Between Tonic Pupils and Argyll Robertson Pupils*

Tonic Pupil	Argyll Robertson Pupil
1. Unilateral, 80 per cent	1. Bilateral, 95 per cent
2. Convergence reaction: (a) Slow gradual contraction (b) Slow gradual dilation	2. Convergence reaction: (a) Prompt contraction (b) Prompt dilation
3. Accommodation reaction: Ciliary muscle may contract and relax slowly	3. Accommodation reaction: Ciliary muscle not affected
4. Light reaction: (a) Slow contraction (b) Slow dilation	4. Light reaction: Absent
5. Dilates normally with atropine	5. Dilates poorly with atropine
6. Normal or semidilated	6. Miotic

atypical phases of the tonic pupil alone, (3) atypical phases of the tonic pupil with absence of tendon reflexes or (4) absence of tendon reflexes alone.

Differentiation from Argyll Robertson pupil,[9] described in 1869, is made on several points (table 1). First, and most important, the tonic pupil contracts slowly in convergence and often only after a considerable

5. Bramwell, E.: The Holmes-Adie Syndrome; A Benign Clinical Entity Which Simulates Syphilis of the Nervous System, Tr. Med.-Chir. Soc., Edinburgh, 1935-1936, pp. 83-92; in Edinburgh M. J., June 1936.

6. Holmes, G.: Partial Iridoplegia Associated with Symptoms of Other Diseases, Tr. Ophth. Soc. U. Kingdom **51**:209-224, 1932.

7. Markus, C.: Notes on Peculiar Pupil Phenomena in Cases of Partial Iridoplegia, Tr. Ophth. Soc. U. Kingdom **26**:50-56, 1906.

8. Nonne: The So-Called Myotonic Slowly Convergent Light Fixed Pupil, Neurol. Centralbl. **21**:1000-1004, 1902.

9. Robertson, D. A.: Four Cases of Spinal Miosis, with Remarks on the Action of Light on the Pupil, Edinburgh M. J. **15**:487-493, 1869.

latent period. Dilation is commonly even slower. On the other hand, the Argyll Robertson pupil contracts and dilates promptly in convergence. The light reaction is frequently apparently absent in the tonic pupil but is usually elicited by exposure to bright light after placing the patient in a dark room for a few minutes or longer. An eye with a tonic pupil may show similar involvement of the ciliary muscle with the resultant complaint of blurred vision for reading or on changing the accommodation of the eye. The tonic pupil usually is semidilated and usually is larger than the pupil of the unaffected eye, while the Argyll Robertson pupil is miotic. The tonic pupil occurs unilaterally in 80 per cent of the cases, but the Argyll Robertson pupil occurs bilaterally in 95 per cent or more. The tonic pupil dilates normally under the influence of atropine, differing from the Argyll Robertson pupil, which dilates poorly. Both possess normal retinal sensitivity. Important evidence is obtained from the Wassermann reaction, since tonic pupil is a nonspecific disorder and Argyll Robertson pupil is nearly always syphilitic in origin. Tonic pupil must always be distinguished from internal ophthalmoplegia and iridoplegia of obscure origin. This should offer little difficulty, for in the latter condition the pupil is rigidly fixed and widely dilated.

The course of Adie's syndrome is benign, the condition remaining stationary. Markus' original patient was seen twenty-seven years later by Weber [10] in 1933, and his condition was unchanged except that the affected pupil was at this time the smaller of the two instead of the larger. The man was still healthy and had a negative serologic reaction; he had married and was the father of two healthy children. Other patients have been observed over a period of several years with no change. Adie characterized the condition as a benign disorder "sui generis." No symptoms are present except occasional photophobia and blurring of vision if accommodation is involved.

The causation is unknown, as indicated by the many theories advanced. The disease occurs most frequently in women (80 per cent) and in the age group between 20 and 30 years. Pupillotonia has been reported occurring in several members of the same family. Dressler [11] in 1937 reported Adie's syndrome associated with hippus occurring in 3 sisters. He examined 13 other members of the same family, of different generations, and found 7 in whom hippus could be demonstrated. He was impressed with the possibility of a relation between tonic pupils and hippus. He felt that they might have the same causative distur-

10. Weber, F. P.: Dr. Markus' Original Case of Markus' Syndrome ("Myotonic Pupil" with Absence of Patellar and Achilles Reflexes) Shown Twenty-Seven and a Half Years Ago, Proc. Roy. Soc. Med. **26**:530-531, 1933.

11. Dressler, M.: Familial Occurrence of Adie's Syndrome with Hippus, Klin. Wchnschr. **16**:1013-1017, 1937.

bance, being familial and possibly hereditary, through a recessive characteristic. In several cases reported hippus has been present, including Saenger's [2] original case and a case of Behr's,[12] the symptom in the latter case developing while the patient was under observation. Most reports fail to mention examination of the rest of the family. Mention has been made by Kennedy and his co-workers [13] of the possibility of its relation to emotional instability, suggested by the work of Ranson and Magoun [14] in stimulation experiments on the hypothalamus and by the fact that the disturbance occurred commonly in emotionally unstable young women. Adie [4] expressed the belief that it may be due to a disturbance in the vegetative nervous system. Behr [12] concluded that it is probably due to a lesion of the vegetative part of the oculomotor nucleus. Jelliffe [15] said that the condition was the result of a mild myxedematous state and treated several patients with thyroid substance, after which the pupil became normal and the tendon reflexes returned. Other causes mentioned by various authors, usually because Adie's syndrome was found associated, are infectious and toxic causes, including syphilis and diphtheria, endocrine disturbances, peripheral and central trauma, congenital anomalies, Thomsen's disease, myasthenia gravis, disease of the basal nuclei, encephalitis and many more. Kennedy and his co-workers [13] well summarized the situation when they said: "To report the syndrome in association with every sort of disease is to widen its significance progressively until it loses all meaning and value, a proceeding which Adie manifestly never intended." It would seem at the present state of knowledge that the cause is not known, that its recognition has no localizing value and finally that its importance lies in distinguishing it from syphilis of the central nervous system.

REPORT OF CASES

CASE 1.—Mrs. M. C., a 28 year old white woman, was admitted to the otolaryngologic service of the Hospital of the University of Pennsylvania on Dec. 6, 1938, with the diagnosis of acute otitis externa of the right ear, though a diagnosis of acute mastoiditis had to be excluded, for in addition to a throbbing earache she complained of pain over the mastoid prominence. She had been well, except for occasional headaches, until December 4, when a sore throat developed and shortly thereafter a severe earache on the right side. According to her past history, she

12. Behr, C.: Concerning the Tonic Convergence Reaction Associated with Pupils Fixed to Light, Klin. Monatsbl. f. Augenh. **66**:770-796, 1921.

13. Kennedy, F.; Wortis, H.; Reichard, J. D., and Fair, B. B.: Adie's Syndrome: Report of Cases, Arch. Ophth. **19**:68-80 (Jan.) 1938.

14. Ranson, S. W., and Magoun, H. W.: Respiratory and Pupillary Reactions Induced by Electrical Stimulation of the Hypothalamus, Arch. Neurol. & Psychiat. **29**:1179-1194 (June) 1933.

15. Jelliffe, S. E.: The Myotonic Pupil: A Concentration and Critical Review. J. Neurol. & Psychopath. **13**:349-357, 1933.

had had whooping cough, measles, typhoid fever and chickenpox, and an ovary and tube had been removed in 1934. She had been aware of unequal pupils since childhood, the right being the smaller. During fits of emotion it was often pinhead in size. Her family history was unimportant. Her profession was that of trained nurse. She was born in Ireland, coming to this country in 1923.

Physical examination revealed the temperature to be 99.2 F., with the pulse and respiration within normal limits. There was so much swelling of the auditory canal as to prevent visualization of the tympanic membrane. Considerable tenderness was elicited by palpating the mastoid region. The submaxillary lymph nodes as well as the right preauricular nodes were bilaterally palpable. Hyperesthesia of the right side of the face was present. The tendon reflexes were absent, which fact was later verified by neurologic consultation.

TABLE 2.—*Pupillary Reflexes of Mrs. M. C. (Case 1)*

	Right Eye	Left Eye
1. Size	4.5 mm.	5 to 7 mm.
2. Convergence reaction		
(a) Contraction	8-10 seconds	Prompt
(b) Dilation	15 seconds	Prompt
(c) Amplitude	Normal	Normal
3. Direct light reaction		
(a) Contraction	Very slow	Normal
(b) Dilation	Very slow	Normal
(c) Amplitude	Small, about 1 mm.	Normal
4. Consensual light reaction	Same as direct light reaction	Normal
5. Dark room (30 min.)		
(a) Contraction	Gradual dilation to 5.5 mm.	Prompt
(b) Dilation	Slow (30 seconds)	Prompt
(c) Amplitude	1.5 mm.	Prompt
6. Accommodation reaction (ciliary muscle)		
(a) Distant to near	6 seconds	Prompt
(b) Near to distant	8 seconds	Prompt
7. Orbicularis reflex	Similar to convergence reaction	Prompt
8. Ciliospinal reflex	No reaction	Dilation

On December 7 an ophthalmologic consultation was requested to help eliminate the possibility of intracranial complication. The patient's vision was 6/9—2 in each eye. External examination demonstrated normal lids, fissures and ocular rotations. Physiologic nystagmus was present on lateral gaze in either direction. Anisocoria was present (table 2), the right pupil measuring 4 mm. and the left 5.5 mm. in diameter. The right pupil contracted slowly in convergence, requiring eight to ten seconds to reach its smallest diameter of about 2 mm., and dilated even more slowly. The reaction to direct and consensual light was almost imperceptible. The pupil remained unchanged to painful stimuli on the neck. The reaction to the orbicularis reflex was the same type as in convergence. The left pupil reacted normally. In convergence, the right pupil remained visibly smaller than the left after allowing time for contraction to take place. The conjunctiva and sclera were normal, as were the cornea and corneal reflexes. Ophthalmoscopic examination gave negative results. Visual fields were within normal limits. Further pupillary studies revealed that the right pupil dilated slowly to about 5 mm. after a few minutes in a dark room, after which a slow contraction to its original size occurred on exposure to bright light, followed again by an almost imperceptible dilation on removal of the light. The ciliary muscle was also

involved. As previously mentioned, the patient's distant vision was 6/9 in each eye. When she was asked to direct the gaze of her right eye from distant vision to Jaeger's test type 1 at 34 cm., she described the sensation of the print as appearing from a fog, and it took six seconds for her to see it clearly. The reverse was also true for this eye; it took eight seconds for her to read the 6/9 line after accommodating for near vision. When the left eye was tested, her accommodation took place and relaxed in a normal manner. Both pupils reacted normally to epinephrine hydrochloride, cocaine hydrochloride, homatropine hydrobromide, pilocarpine nitrate and physostigmine salicylate (table 3). On one occasion she was given an intramuscular injection of 1.5 mg. of prostigmine combined with 0.01 grains (0.00065 Gm.) of atropine sulfate, but this had no effect on either the pupillary reaction of the right eye or the tendon reflexes. The right pupil constricted markedly (fig. 1) o instillation of a 2.5 per cent solution of acetylbetamethylcholine chloride (mecholyl), 1 drop in each eye repeated in five minutes. The left pupil was not affected.

TABLE 3.—*Pupillary Responses of Mrs. M. C. to Drugs*

Drug	Right Eye	Left Eye
Epinephrine hydrochloride	Slight change	Slight change
Cocaine hydrochloride	Good dilation	Same as right eye
Homatropine hydrobromide	Good dilation	Same as right eye
Physostigmine salicylate	Contraction to 2 mm.	Same as right eye
Prostigmine		
(a) 1.5 mg. intramuscularly	Unchanged	Unchanged
(b) 1:2,500 by conjunctival instillation	Unchanged	Unchanged
Mecholyl	Contraction to 2 mm.	No contraction
Mecholyl and prostigmine	Slightly in excess of reaction to mecholyl alone	No contraction
Acetylcholine	Contraction to 2.5 mm.	No contraction

All laboratory studies, including blood counts, urinalyses, determination of the blood urea nitrogen, serologic study of the blood and spinal fluid and determination of the colloidal gold curve, gave negative results. Roentgenograms of the mastoid region and paranasal sinuses were negative. The basal metabolic rate was —10 per cent.

Since the foregoing studies, the patient has been delivered of a normal full term baby girl, born on Oct. 4, 1939. The child's pupils react normally.

CASE 2.—E. O., an 18 year old white girl, was seen on March 13, 1939. Ophthalmologic consultation had been requested because of an absence of the light reaction in the pupil of her left eye, noted at routine physical examination. The patient had no ocular complaints but stated that she had been aware of unequal pupils since 9 years of age. Her past medical history was essentially unimportant. She had never suffered from any ocular trouble. Her vision was 6/9—2 in each eye without correction, being 6/7.5 in each eye with a moderate correction for combined hyperopic astigmatism. Accommodation was prompt. The near points of accommodation were 10 cm. in the right eye and 9 cm. in the left eye. One prism diopter of exophoria was found for distant vision, with 2 prism diopters of exophoria for near vision. External examination revealed anisocoria, the right pupil measuring 6 mm. and the left 4.5 mm. in diameter. The right pupil reacted normally to all stimuli. The left pupil contracted slowly, it requiring twelve seconds for the pupil to reach its minimum size of 2.5 mm. in convergence. Dila-

tion on withdrawing the stimulus was even slower, requiring twenty-five seconds. The light reaction could be seen only with the slit lamp, when it was seen to be tonic and of small amplitude. Half an hour in a dark room allowed the pupil to dilate to 5.5 mm., after which the light reaction, while still slow, was of fair amplitude. The irides appeared entirely normal. No changes in the anterior segment of the eye were found with the slit lamp. Ophthalmoscopic examination gave negative results. The pupils dilated normally on instillation of homatropine hydro-

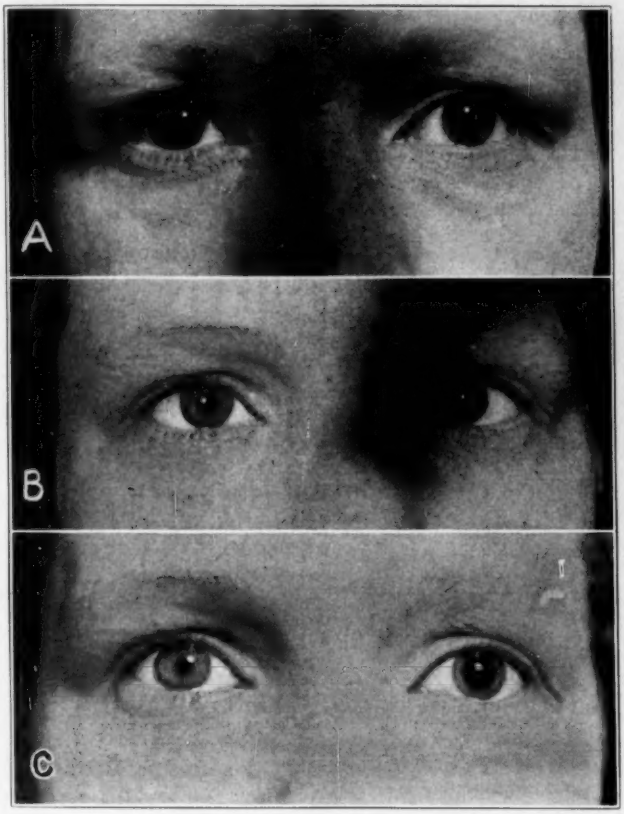

Fig. 1.—Patient with tonic right pupil. *A* shows the appearance of the pupil with the patient looking into infinity before the instillation of mecholyl. *B* shows the size of the pupils on convergence. *C* shows constriction of the right pupil one-half hour after instillation of mecholyl.

bromide and cocaine hydrochloride. No sensitivity was present to epinephrine hydrochloride. A 2.5 per cent solution of mecholyl instilled into both eyes contracted the left pupil to 2.5 mm. in fifteen minutes with further constriction by one-half hour. It had no effect on the right pupil. A Wassermann reaction of the blood was negative. The tendon reflexes were all present.

Case 3.—Mrs. H. M., a 39 year old white woman, had been aware of having "peculiar" pupils since 10 years of age. She had always noticed that it took

some time to focus her eyes from far to near objects. At the time of her marriage, at 21 years of age, a diagnosis of congenital syphilis was made and antisyphilitic therapy advised. Serologic studies of the spinal fluid done on two occasions were negative, as well as repeated Wassermann tests of the blood, the last being made in 1935. The patient's general health had always been good. Her vision was 6/6 in each eye, with a small correction for combined hyperopic astigmatism. The near points of accommodation were 18 cm. in the right eye and 24 cm. in the left, with correction, for 0.75 meter test type. One prism diopter of exophoria was found

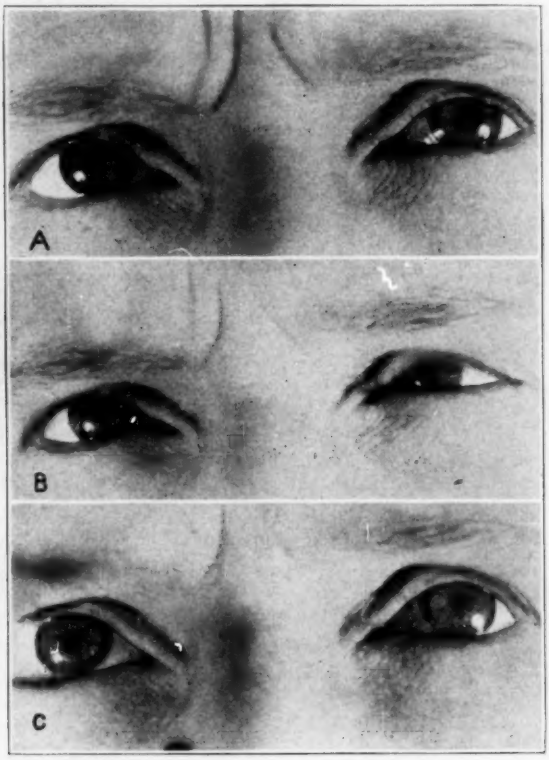

Fig. 2.—Patient with bilateral tonic pupils. *A* shows the appearance of the pupils with the patient looking into infinity before the instillation of mecholyl. *B* shows the size of the pupils on convergence. *C* shows bilateral constriction one-half hour after instillation of mecholyl.

for distance. External examination revealed anisocoria, the right pupil measuring 4 mm. and the left 3.5 mm. in diameter. Both pupils were slightly irregular, the right horizontally oval. No light reaction could be elicited. The convergence reaction was very tonic in both eyes, ten seconds being necessary for their contraction to 2 mm. The subsequent dilation was completed only after forty-five seconds. No abnormality of the irides could be found with the slit lamp. Ophthalmoscopic examination revealed nothing abnormal. Since time permitted but one visit, her pupils were tested only for mecholyl, which constricted both pupils to 1.5 mm. in twenty-five minutes (fig. 2). The tendon reflexes were all present.

CASE 4.—Mrs. P. W. J., a 60 year old white woman, seen by permission of Dr. Francis Heed Adler, presented only presbyopic symptoms. On several occasions inquiry had been made by physicians as to her pupils, fairly extensive studies having been done on two occasions. Her general health had been good. Her vision was 6/6 in each eye with correction for combined hyperopic astigmatism. Two diopters of esophoria existed for distant vision, with orthophoria for near vision. External examination revealed miotic pupils, with anisocoria, the right pupil measuring 2.5 mm. and the left 3.5 mm. in diameter. The right pupil reacted promptly in accommodation, though the reaction was of small amplitude

Fig. 3.—Patient with tonic left pupil. *A* shows the appearance of the pupils with the patient looking into infinity before the instillation of mecholyl. *B* shows the size of the pupils on convergence. *C* shows constriction of the left pupil one-half hour after instillation of mecholyl.

due to the miosis. The light reaction was normal. The left pupil contracted to 2 mm. after twelve seconds, dilating even more slowly for thirty-five seconds after the stimulus was removed. No light reaction could be seen with the naked eye, although it was just perceptible with the slit lamp. Slit lamp examination demonstrated many fine punctate pigmented deposits on the corneal endothelium. No synechiae were present, but evidence of atrophy of the iris was seen. Nothing was found ophthalmoscopically except a few opacities of the vitreous. One drop of 2.5 per cent solution of mecholyl in each eye, repeated in five minutes, con-

stricted the left pupil to 1.5 mm. in thirty minutes (fig. 3). No effect was noted on the right. The Wassermann reaction of her blood was normal. All tendon reflexes were present.

CASE 5.—Miss B. S., a 26 year old white woman, seen by permission of Dr. Francis Heed Adler, complained of slight discomfort of her right eye. Her general health was good. No history of previous ocular trouble was elicited. Her vision was 6/6 and 6/7.5 in the right and the left eye, respectively, with a moderate correction for combined hyperopic astigmatism. The near points of accommodation were 12 cm. in the right eye and 15 cm. in the left eye, with 0.75 meter test type. One prism diopter of esophoria was present for distance. Accommodation was prompt. The right pupil was 4 mm. and the left 5 mm. in diameter. The right pupil was vertically oval. Both pupils promptly, but very slowly, contracted 1 mm. in convergence. Relaxation was even slower, requiring twenty seconds. A similar contraction occurred to light, but only after a longer latent period, and the amplitude was less. Dilation was similar. Slit lamp examination showed considerable deposition of pigment on the posterior surface of the cornea. No change was found in the irides. The fundi were normal. Both pupils dilated well on the instillation of homatropine hydrobromide. After instillation of 2 drops of 2.5 per cent solution of mecholyl, five minutes apart, in each eye, the pupils constricted to 2 mm. at the end of thirty minutes. All tendon reflexes were normal. The Wassermann reaction of the blood was negative.

CASE 6.—Mrs. H. R. H., a 36 year old white woman, was first seen, by permission of Dr. Francis Heed Adler, on July 25, 1938, at which time she complained of unequal pupils of one month's duration. No other symptoms were noted. Her general health was fair. She had been under rather severe nervous strain for several months. She had never had diphtheria. Four children were living and well. There had been one ectopic pregnancy and one miscarriage between the second and the third child. The family history was of no consequence.

Her vision was 6/7.5 in the right eye and 6/6 in the left with a moderate correction for mixed astigmatism in each. The near point of accommodation for the right eye was 18 cm. and for the left eye 20 cm. One prism diopter of exophoria was present for distance. The right pupil was 3.5 mm. and the left 5 mm. in diameter. The right pupil reacted promptly to light. The left pupil reacted slowly to light, the amplitude being small. The right pupil contracted normally in convergence. It required twelve seconds for the left pupil to complete contraction and twenty-five seconds for it to dilate. Slit lamp examination revealed no pathologic ocular changes, but it was noticed that there was practically no contraction of the left iris from 6 to 11 o'clock on exposure to light. The fundi were normal.

General physical examination demonstrated a mild anemia. The hemoglobin content was 70 per cent. The Kahn and Wassermann reactions of the blood were negative. The patient was asked to report for further observation in six months.

When she was next seen, on Feb. 17, 1939, the only change in findings recorded was a recession of the near point in the left eye from 18 cm., previously recorded, to 25 cm. She did complain of her eyes tiring and burning after reading. This symptom became worse during the following month. On March 21 the near point was 31 cm. At this time a +1.00 D. hook-on glass was ordered to be worn over the left eye for reading. This relieved her symptoms. At this time 2.5 per cent solution of mecholyl was instilled into both eyes, without effect on the right eye; the left pupil contracted from 6 mm. at instillation to 3.5 mm. in one-half hour, and the near point was brought to 23 cm. The patient was given a solution of mecholyl to use at home at fifteen minute intervals while reading and noticed

that it greatly relieved her symptoms, even without the hook-on glass. A solution of epinephrine hydrochloride (1 : 1,000) had no visible effect on either pupil. Both pupils dilated well on instillation of homatropine hydrobromide.

On the patient's next visit, on June 21, 1939, she was again having difficulty with reading. The near point of accommodation for the left eye was now 45 cm.; it was still at 18 cm. for the right eye. A + 2.00 D. sph. addition was ordered. At this time examination by a neurologic consultant revealed diminution of the right knee and ankle jerk.

COMMENT

Six cases of Adie's syndrome are reported. The diagnoses were made by physical examination and corroborated by serologic studies. In 2 of the cases the syndrome was of the complete form; in 1 of these cases there was only diminution of a knee and an ankle jerk and in the other complete absence of all tendon reflexes. The condition in the remaining cases conformed to the incomplete type, with tonic pupils alone. In 2 cases the ciliary muscle was involved, as shown by objective tests, and in a third accommodation was sluggish subjectively. In all of the cases there was the typical tonic pupillary reaction in convergence followed by slow dilation and a reaction to light that was difficult to elicit. In 2 cases the pupillary phenomena were bilateral. They all occurred in white women from 18 to 60 years of age. In all of the patients but the one 36 years of age the condition had been present for many years or since childhood. The 36 year old patient (case 6) gave a reliable history of anisocoria of one month's duration. No involvement of the ciliary muscle was noticed at the first visit, but during the following year the near point of accommodation of the affected eye receded till a + 2.00 D. addition was needed for reading. Accommodation had become definitely slow on the affected side, requiring three seconds.

In testing the reaction of the pupils to drugs, both pupils in case 1 responded normally to cocaine hydrochloride, epinephrine hydrochloride and homatropine hydrobromide, giving proof that the pupillodilator mechanism was functioning normally. The pupils of the other patients could not be tested with all of these solutions, though all the pupils tested with homatropine hydrobromide dilated normally and the pupil tested with epinephrine hydrochloride was not sensitized. Furthermore, in case 1 physostigmine salicylate and pilocarpine hydrochloride contracted both pupils equally well, showing that the sphincter muscles must have been functioning. This, of course, was also shown by the contraction to light and in convergence. Prostigmine had no effect on the pupillary reactions; hence myasthenia gravis could be ruled out as an etiologic factor.

Of extreme interest was the marked constriction of the affected pupil in all of the cases after the instillation of a 2.5 per cent solution of mecholyl, a stable choline substance. The unaffected pupils were not contracted, nor were those of 50 normal controls. The condition in all

of the cases seen was diagnosed clinically as Adie's syndrome, and the pupils were then tested with mecholyl in an attempt to approach the disturbance pharmacologically. In no case was the condition designated as Adie's syndrome because of the response of the pupils to mecholyl, nor was the diagnosis discarded because of the lack of it. In addition to contraction of the tonic pupil in case 6, in which the ciliary muscle was also involved, the near point was improved 8 cm. and the patient could read with greater facility after the instillation of mecholyl.

To explain the possible significance of this, it might be well to consider the work of Loewi, Dale and others, which is well summarized by Cannon and Rosenblueth,[16] on the mechanism of transmission of a nerve impulse from the nerve ending to the effector cell, whether it is muscle, gland or other tissue. They showed that when a nerve impulse has traveled down a nerve to its ending a substance is liberated which activates the effector cell to perform its physiologic function. If this is either a parasympathetic nerve ending or the ending of a nerve to a striate muscle, acetylcholine is liberated, causing the effector cell to react. If it is a sympathetic nerve ending, sympathin, an epinephrine-like substance, is set free. It is also known that if the nerve supply is interrupted postganglionically and the nerves allowed to degenerate, the effector cell becomes sensitized to the substance formerly liberated by the nerve ending and responds to smaller amounts than formerly. This sensitization phenomenon in the radial fibers of the iris was observed and clarified by the work of Anderson [17] in 1903, Meltzer and Auer [18] in 1904 and Elliott.[19] It explains the dilation of a pupil by epinephrine hydrochloride in an eye in which Horner's syndrome has been produced by removing the superior cervical ganglion. This is because the radial dilator muscle fibers have been sensitized to epinephrine by loss of their sympathetic supply. Shen and Cannon [20] removed the ciliary ganglion of cats and observed that the sphincter muscle supplied by parasympathetic nerves becomes sensitized to acetylcholine in the denervated eye, since the pupil constricted on instillation of the substance, while the eye which was not operated on did not respond. The fact that the tonic pupil in the cases being reported contracted on instillation of mecholyl suggests that the patients had suffered a lesion affecting the parasympathetic supply to the iris at the ciliary ganglion or peripheral to it.

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16. Cannon, W. B., and Rosenblueth, A.: Autonomic Neuro-Effector Systems, New York, The Macmillan Company, 1937.

17. Anderson, H. K.: Reflex Pupil-Dilatation by Way of the Cervical Sympathetic Nerve, J. Physiol. **30**:15-24, 1903.

18. Meltzer, S. J., and Auer, C. M.: Studies on the "Paradoxical" Pupil-Dilatation Caused by Adrenalin, Am. J. Physiol. **11**:28-39, 1904.

19. Elliott, T. R.: The Action of Adrenalin, J. Physiol. **32**:401-467, 1905.

20. Shen, S. C., and Cannon, W. B.: Sensitization of the Denervated Pupillary Sphincter to Acetyl Choline, Chinese J. Physiol. **10**:359-372, 1936.

Bender and Kennard [21] recently showed that after section of the facial nerve in monkeys a minute intravenous injection of acetylcholine causes a slow contraction of the paralyzed muscle, sensitization having occurred. They also described the so-called "fright reflex," which was seen to be a slow contraction of the denervated facial muscles beginning in two to three seconds after frightening the monkey and lasting thirty to forty seconds. They attributed this fright reaction to the increased amount of circulating acetylcholine produced by the excessive nervous activity in fright acting on the sensitized tissue. It is therefore possible that the miosis described in case 1 during the periods of emotion is similar to and on the same basis as the phenomena just described. If this is true, it gives further evidence pointing toward a denervation of the sphincter muscle. None of the other patients had observed their pupils during emotional stress.

From this information it seems justifiable to postulate a plausible theory as to the site of the disturbance of Adie's syndrome. The lesion would have to be placed in the parasympathetic system at the ciliary ganglion or peripheral to it to explain the sensitization to choline. This denervation would have to be partial, since the sphincter muscle does respond to physostigmine salicylate, which substance can act only in the presence of intact nerve endings, and also because reaction in convergence and to other pupillary reflexes is present though tonic. The tonic contraction might be explained by the slow diffusion of acetylcholine, liberated by the few functioning parasympathetic fibers, through sensitized sphincter muscle, and the slow dilation occurs as the acetylcholine is destroyed by its esterase, allowing relaxation of the sphincter. An objection to the hypothesis is the lack of explanation of the absence of tendon reflexes. Their significance, however, is still questioned by many observers. If they are an essential part of the syndrome, the disorder would have to be generalized, and certainly bilateral pupillary involvement would be expected in a greater number of cases.

SUMMARY

Six cases of Adie's Syndrome are reported.

The affected pupils were all sensitized to mecholyl.

The site of the lesion is postulated as being a partial parasympathetic denervation peripheral to the ciliary ganglion.

The importance of distinguishing it from tabes dorsalis with Argyll Robertson pupils is reemphasized.

21. Bender, M. B., and Kennard, M.: The Fright Reaction After Section of the Facial, Trigeminal, and Cervical Sympathetic Nerves, J. Neurophysiol. **1**:431-435, 1938.

CORNEAL TRANSPLANTATION

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Tribute in appreciation is respectfully paid to the pioneers and to contemporaries in the work of corneal transplantation. Through their achievements, this operation has been successfully developed to an established entity in the ophthalmologic world. It is important to note that this success has not been confined to any isolated technical procedure or instrumentation but rather to the several known methods which the literature describes. Representative of this are the work of von Hippel,[1] Elschnig,[2] Filatov,[3] Thomas[4] and Castroviejo.[5] For the many others whose works are worthy contributions, the reader is referred to the treatises of these men and their accompanying bibliographies. While this noteworthy success has been gratifying, the ophthalmic surgeon is not likely to admit that its meridian has been attained. Hopes for additional progress are fundamentally twofold, namely, to obtain a greater percentage of successful operations and to procure a still better visual status in those cases in which the operative results are correctly classified as successful.

EXPERIMENTAL WORK

A small series of experimental corneal transplantations (circumscribed penetrating) was undertaken on rabbits to acquire some first hand information as to the efficacy of the various steps in operative procedure. Until a satisfactory graft was obtained, repeated failures occurred. In these cases the transplants became opaque. In some, the iris had become attached to the wound (anterior synechiae). When conjunctival flaps were used, there were infections and subluxations of the disk transplant. These failures were mostly due to faulty operative technic while gaining

1. von Hippel, A.: Eine neue Methode der Hornhauttransplantation, Arch. f. Ophth. (pt. 1) **34**:108, 1888.

2. Elschnig, A.: Ueber Keratoplastik, Ber. ü. d. Versamml. d. deutsch. ophth. Gesellsch. **42**:331, 1920.

3. Filatov, V. P.: Zur Technik der partiellen durchgreifenden Keratoplastik, Ztschr. f. Augenh. **65**:147, 1928; Transplantation of Cornea, Arch. Ophth. **13**:321 (March) 1935.

4. Thomas, J. W. T.: The Technique of Corneal Transplantation, with Recent Modifications, Tr. Ophth. Soc. U. Kingdom (pt. 2., 1937) **57**:520, 1938.

5. Castroviejo, R.: Keratoplasty: An Historical and Experimental Study, Including a New Method, Am. J. Ophth. **15**:825, 1932; Present Status of Keratoplasty, Arch. Ophth. **22**:114 (July) 1939.

experience, and some could be attributed to outright experimentation with irregular procedures. While certain observations will be made regarding this work, it is inadequate for any demonstrable conclusions and will not be reported in detail.

In preparing for this experimental work it was necessary to make a choice of operative procedure and to give some thought to theoretic considerations. In this analysis an attempt was made to ferret out both advantages and disadvantages wherever found. There are other factors besides the operative procedure which contribute to the successful operation. Exceptional skill, the result of native ability, practice and experience, will frequently overcome a specific handicap of operative technic. Therefore, this analysis is concerned with the separate steps of operative technic and for the present is not influenced by the results already reported.

Based on the instruments used, one may divide the modern operations of corneal transplantation into three types as follows: (1) operative technic for which twin blades and a keratome are used, (2) that for which the automatic trephine, mechanical or electric, is used and (3) that for which the hand trephine is employed.

Obviously, a final comparison of the merit of these three instruments and of the various steps of the individual operative procedure must await the opportunity for extensive practical application. As keratoplasty is a specialty within a specialty, only a few operators will have such an opportunity.

THEORETIC CONSIDERATIONS

Before any comparison of these three types of operations is made, certain general phases of the problem should be considered. These generalities apply to all three types, but because of their nature they will affect one operative procedure more than another.

The microscopic thickness of the separate layers of the cornea vary in different eyes; consequently, when coaptation of two tissues is attempted their corresponding layers will not always meet accurately. This is approximation, not true apposition. There may be variations in the character and number of the cellular elements. Different sections of the separate layers vary in thickness. Each cornea has its own degree and character of astigmatism. When the transplant is removed from the donor eye, its arc flattens, losing its original radius of curvature. Astigmatic changes of the recipient cornea may also occur during the operation. The amount of plasma absorbed by the excised transplant and that of the severed edges of the recipient cornea must be considered and contrasted. The measurement of the graft and the aperture should match, with the exception of a slight uniform reduction in size of the graft. This is necessary because of some of the factors already mentioned. To restate a fundamental, in the approximation of the corneal edges

forming the aperture and those of the donor graft, any variation in the thickness or position of the separate layers of the two edges of the tissue must influence the primary healing and later transparency of the transplant.

TWIN BLADES AND A KERATOME

The incisions made with twin blades require mathematical accuracy in producing a true rectangle. While apparently this is not difficult, it is subject to human error.

Crossed incision lines extending beyond the corners of the rectangle are necessary in using the twin blades. This creates loose angulated areas of tissue in the recipient cornea. The total length of the edges of the oblong transplant is greater than the circumference of the circular disk. Increased length of the wound means added trauma and necessarily more reparative activation.

A straight linear incision should be more cleancut than a circular one. What percentage of difference in linear precision should exist between a properly executed trephine cut made with a truly sharp blade and the same made with a twin blade is problematic. The advantage is on the side of the straight cut.

The incision made with the twin blades does not have the uniformity of depth of the cut made with the trephine. Experience will add to the accuracy of this phase of the incision made with the twin blades, but unless the consistency of the tissue is uniform and a perfectly steady pressure is maintained with the blades for all incisions, its depth will be subject to repeated variations. Differences in the degree of corneal penetration are possible (*a*) between the primary incisions of the donor graft and the recipient cornea, (*b*) between the horizontal and the vertical incisions, (*c*) between the incisions of the separate blades and, finally, (*d*) in the course of the individual incision.

Penetration of the anterior chamber is not a likely possibility, but it should be mentioned. Its occurrence during the primary incisions of the twin blades would considerably complicate the operative procedure. The incision with the keratome is also subject to repeated variations.

The position at which beveling is begun will depend on the depth and the accuracy of the primary incisions; otherwise, the straight incision favors accurate beveling of the posterior corneal tissue. This advantage over the circular cut is not present when the four corners are beveled. Rather, certain hazards must be considered. Laceration of the tissue angles may occur, and the irregularities of thinning or lumping of the corner tissues are possibilities.

The greatest objection to the twin blades is found in the necessity of approximation of the four angular corners. Tissue corners frequently heal poorly. Their ends devitalize, curl, depress and in general seldom truly approximate. This becomes of even greater import when added

to this handicap are the possible discrepancy in measurement between the aperture and the transplant and the variation in thickness and curvature between the graft and the recipient cornea.

THE AUTOMATIC TREPHINE

When it is under complete control of the operator, the automatic trephine, owing to its speed of operation, should cut with slightly more precision than the hand trephine. The degree of difference is problematic. It is in the control of this necessary bulky instrument that its disadvantage lies. Under the strain of delicate operative procedure, a cumbersome instrument, driven by a mechanical or electric motor, cannot be sensitively maneuvered. It does little to steady one's nerves at a crucial moment. The potential danger of injury to the iris and lens is increased. On this account certain operators have found a protective spatula necessary. Others use a shoulder or cuff which limits the penetration of the blade. In so doing, this depth must be predetermined. With too much caution, less of the deeper corneal layers are incised than would be possible without the use of a cuff. Accidental penetration of the anterior chamber is fraught with danger, and when the anterior chamber is intentionally opened, extreme care must be used.

THE HAND TREPHINE

The simplicity of the hand trephine recommends its use to most ophthalmologists. The refinement permitted in its use is in keeping with the delicacy of operative work on the eye. Both the automatic and the hand trephine have the advantage of accuracy of measurement as desired. The circular transplant is the most logical shape to fit the arched cornea in the eye, where curves are the order and not sharp angles; i. e., the structural contour of the cornea, the limbus, the pupil, the iris and the lens must be considered. One may anticipate that with truly sharp blades of excellent steel, with a closer familiarity with the hand trephine and with more experience in operating any objections of insufficient precision in cutting will be eventually minimized.

The single cut of the trephine, compared with the necessary four cuts of the twin blades, has the advantage of a closer approach to uniformity of depth. However, as with the twin blades, a difference in the degree of corneal penetration is possible between the primary incision of the donor graft and that of the recipient cornea.

Circular beveling of the posterior corneal tissue, while fairly accurate in uniformity of depth, at present must produce a tissue shelf lacking in symmetry. Because of the circular manner of cutting and the necessary snipping, there are frequently weak areas in which the capacity for support is inadequate. Apparently this effect is usually overcome by the

remainder of the tissue bevel. Notwithstanding this problem, with proper knowledge of the subject and with meticulous care, a fair degree of success may be expected. A remedy for this difficulty might be found in a newly designed instrument which would assist in more effectively performing this special phase of the operation.

Were it possible to obtain perfection in beveling of the tissues forming the two types of apertures—the rectangular and the circular—the structural continuity of the latter should offer the better support to the transplant.

THE STABILIZING HAND TREPHINE

In a further study of the hand trephine, attention was directed toward the possibility of designing an instrument which would have a greater stability and accuracy in its application and would afford a better control; in consequence, more precision could be expected in making the trephine cut. To this end the stabilizing trephine was hopefully designed.

The new trephine is of average size as compared with other hand trephines. Without the blade, it measures 60 mm. in length. The end

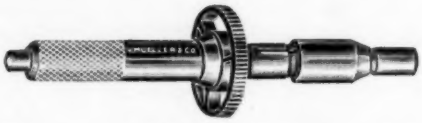

Fig. 1.—Stabilizing trephine with blade.

of the upper shaft is corrugated. The end of the lower shaft has the usual chuck for the insertion of the various-sized trephine blades. Protective cuffs regulating the depth of penetration have not been found necessary. The corneal transplant blades measure 4 and 4.05 mm. in diameter. Other sizes can be furnished on request, including trephine blades for the Elliot corneoscleral operation. The feature of the new trephine is a stabilizing wheel, which is situated slightly below the center of the shaft. This is a three sprocket wheel measuring 20 mm. in diameter. A portion of the shaft is smoothly ground and serves as an axle for the wheel's central opening. Welded circular metal rings support the wheel above and below. The wheel is mechanically balanced and revolves when operated with a free uniform movement.

MANNER OF USE OF HAND TREPHINE

The sitting position for the operator reduces his nervous tension and improves the chances for operative dexterity. In using this instrument while operating on the human eye, the operator should face the temporal side of the eye. The hands are properly braced as for other operative procedures. With the left little finger acting as a brace, the remaining fingers which support the trephine are elevated or depressed, regulating

its perpendicular movement. The stabilizing wheel is gently grasped and held between the left thumb and the left index finger. The shaft is kept accurately erect. The middle finger rests below the wheel alongside the lower shaft. In placing the trephine blade in the exact position chosen, the middle finger acts as an excellent steadying medium for lateral movements. As soon as the incision is begun, the middle finger is removed from the shaft. The right thumb and the right index finger rotate the upper shaft. These maneuvers should be first repeatedly practiced on modeling clay. Here emphasis must be placed on the precise position of the shaft and on the developing of steady dependable vertical and lateral movements of the blade. One should be able to rotate the blade a fraction of a millimeter above the substitute cornea without any incision and at will depress the shaft slightly and then uniformly incise. Precision or the lack of it may be accurately studied in the circular cut in clay. In regular operative procedure, after a certain penetration of the cornea the shaft is tilted to a specified angle to open the anterior chamber.

The practice of outlining the trephine incision with a preliminary cut and then reapplying the trephine can be improved to where only one application of the blade is made. Careful study of the cornea, proper insertion of the sutures and study of the position of the blade before applying it will make this possible.

OBSERVATIONS RELATING TO OPERATIVE TECHNIC

Corneal transplantation is an operation that requires the best in operative skill. Considerable laboratory study and animal experimentation are essential to the proper understanding of its problems and to the development of an excellent operative technic.

After beginning with modeling clay, one can use 6 week old kittens' eyes to study the suture technic, to practice using the trephine and to give special attention to the technic of beveling. Finally, live rabbits will be necessary to deal with the peculiar problems of living eye tissue, especially the iris and the aqueous, and also to study the eye postoperatively and later the reparative processes. This should be followed by microscopic study of the healed tissue.

Of major importance is the sharpness of the trephine blades. After they are obtained from a reliable source, they should not be handled by any one unfamiliar with this work. Blades which are dropped or the edges of which are brushed against even soft material should not be used. Of course, a newly sharpened blade for each separate trephine cut is imperative. The alert ophthalmic surgeon will always have extra blades for the emergency.

Before operating, one should completely examine the eye. The cornea should be minutely studied with a loupe and oblique illumination, by transillumination and finally with a slit lamp. A clear mental picture of its peculiar configuration, size, shape and location of opacities must be made. The exact position for the trephine must be predetermined. Sketches will assist materially.

Conjunctival flaps were found unsatisfactory in this experimental work on rabbits. In postoperative care, asepsis was found impossible. For obvious reasons, in this respect this work differs from the operation on the human eye. However, certain comparisons may still be considered. While flaps are easily made, they change a clean, precise, methodical operation into one that is delayed and comparatively messy. Because of the trauma of separated conjunctiva and raw and occasional necrotic edges, the danger of infection is increased.

Further, the lines of fixation of the conjunctival flaps are considerably beyond the corneoscleral junction. An irregular drag of the flaps must be expected during extraocular muscular movements. While the anterior chamber is reforming, the graft is subjected to the necessarily increasing intraocular pressure. Here the far removed attachments do not afford the accurate firm support of the disk transplant, as is found when cross sutures are used. The danger of subluxation of the disk is greatly increased.

In this work on rabbits, with the exception of the operative steps which were experimental, the Thomas technic was followed with certain variations. When the conjunctival flap technic was not followed, a single cross suture was tried. In contrast, Thomas uses two separated, more or less vertical sutures which traverse the implant, crossing at the center. Similarly, there are two horizontal sutures. Protective pressure is thus applied at eight peripheral radiations. This is twice the number of radiations of the simplified cross suture. In this small number of cases the simplified technic was effective in maintaining the position of the implant during healing, without either subluxation or fistulization occurring. For the present, this suture must be regarded as purely experimental. Should it prove to be of merit, it has certain advantages.

The application of this suture is less time consuming than the Thomas suture. There are a lesser number of crossing sutures to manage and lay on the surface of the graft. However, because of the reduced number of sutures there will be a greater need for accuracy. The angles of the cross must be true, and the cross must be accurately centered. Its description is as follows:

The vertical bar of the cross suture is made first. If the right eye is being operated on, one begins at the inferior pole; if the left eye, at

the superior pole, i. e., to the operator's right. With the operator's right hand pointing to his left, the insertion of both the upper and the lower corneal needle is directed temporally, i. e., toward the operator. The first insertion is made 1.5 mm. from the proposed trephine cut. The bite approximates 2 mm., i.e., 1 mm. on either side of the central vertical line. Its depth is slightly less than one-half the thickness of the cornea. It is tied with a square knot, with the knot exactly central. (Sliding the knot to either side before tying may be used to correct an inaccurate position of the suture lines.) Crossing the corneal vertex, the needle enters again 1.5 mm. from the proposed trephine cut, a trifle nasally from the exact center, to allow for traction (about 0.25 to 0.5 mm.). The needle is pointed obliquely to the temporal side, where it is inserted more or less parallel with the proposed trephine cut for a distance of approximately 2 mm. Another similar suture with identical measurements crosses the vertical bar at right angles. This is begun at the nasal side. After travers-

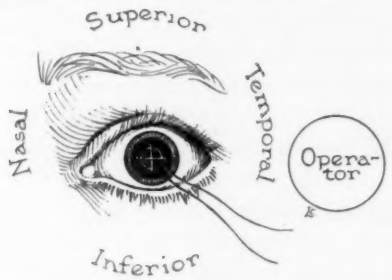

Fig. 2.—Simplified cross sutures, two separate sutures being used.

ing the cornea, the needle enters a trifle to the operator's right of the central horizontal line. Pointing obliquely, it is inserted more or less parallel with the proposed trephine cut in the direction of the free end of the first suture. The distance between the entrances of the two needles may be divided into thirds—a third for each suture and a remaining third of corneal surface for tying. The threads are left loose and may be used for slight traction during the operation. Eventually, when the edges of the implant have been carefully inspected and given their necessary care, the sutures are tied with a square knot.

The trend of the operative procedure of corneal transplantation should be toward the elimination of unnecessary trauma to tissue and toward simplification of its technic. To illustrate, the insertion of the protective spatula at the limbic region causes extra trauma and disturbs the normal physiologic and reparative processes. It scarcely seems likely that the future operation will necessarily include this operative procedure.

Experimental work should be undertaken with larger size trephine blades. Even though the length of the wound will be increased by this

change, the center of the disk will be further removed from the area of traumatic cellular reaction and infiltration. There is the possibility that in some cases a larger transplant would increase the chances for central transparency of the transplant.

SUMMARY

An effective simplified technic should be the goal for the work of corneal transplantation.

In a careful study of the coaptation of the edges of the recipient cornea and the donor graft, the following factors should be considered: (1) comparative thicknesses—local and general and preoperative and postoperative—of the corresponding individual layers of the two corneal tissues; (2) radius of curvature of the two tissues; (3) corneal astigmatism — preexisting and newly formed; (4) comparative measurement between the aperture and the donor graft, with allowance for a slight uniform reduction in the size of the graft; (5) degree of linear regularity of the incised edges; (6) uniformity in the depth of the primary incisions; (7) symmetry of the beveled posterior corneal tissues and (8) comparative positions of the edges of the tissue along the entire length of the wound.

It is structurally impossible to produce an accurate apposition of the separate layers of the host and donor corneal tissues. What is obtained is mere approximation. However, the nearer one approaches true apposition the greater are the chances for a successful operation.

A theoretic comparison is made of the operative procedures using the twin blades and the keratome, the automatic trephine and the hand trephine. While there is obvious merit in all of the three methods, the hand trephine technic is recommended because I believe it embraces the necessary elements toward which the future development of corneal transplantation should be directed. It likewise should be more suitable for the needs of the majority of ophthalmologic surgeons. Accurate comparison, in the last analysis, however, must rest with those having the opportunity for considerable actual experience.

An improved trephine, the stabilizing corneal trephine, is presented.

Observations relating to operative technic are made, including the description of a simplified cross suture.

Obviously, further experimental work is needed and should be encouraged.

PHI PHENOMENON AND ANOMALOUS PROJECTION

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If the eyes are exposed to an external visual stimulus, then this is quickly extinguished and the eyes are exposed to a similar stimulus from a different place, the two stimuli may be perceived as a single stimulus which has moved across the intervening space. Such apparent motion was first investigated by Exner [1] in 1875 and given the designation "Phi phenomenon" by Wertheimer [2] in 1912. Since the advent of advertising signs which utilize this phenomenon, it has become generally familiar. It has been extensively investigated,[3] and much is now known as to the conditions which are most apt to elicit it, including the time and space intervals. Experimental conditions have been produced under which the observer cannot distinguish between the apparent movement in the Phi phenomenon and actual movement when the conditions for one are substituted for those of the other. It is known that the phenomenon can occur during either monocular or binocular vision and also when one stimulus is presented to one eye only and the other stimulus to the other eye only (contraocular Phi). Under suitable conditions, the apparent motion may occur in depth and even when the depth is dependent solely on binocular stereopsis.

Monocular Phi may always be easily produced by occluding one eye and suddenly dropping a prism before the other eye while observing any test object. To the ophthalmologist, contraocular Phi is a common phenomenon, for it is observed by most patients with presumptive heterophoria when they are subjected to the cover test—the test object appears to jump from one position to another. A peculiar type of contraocular Phi, which so far as I know has not been elsewhere discussed, results when diplopia of an object is produced by convergence, divergence or a prism and then one eye is suddenly occluded. Instead of

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1. Exner, S.: Ueber das Sehen von Bewegungen und die Theorie des zusammengesetzten Auges, Sitzungsb. d. k. Akad. d. Wissensch. (1875) **72**:156, 1876.

2. Wertheimer, M.: Experimentelle Studien über das Sehen von Bewegung, Ztschr. f. Psychol. **61**:161, 1912.

3. A somewhat comprehensive discussion of the phenomenon is given by M. D. Vernon (Visual Perception, London, Cambridge University Press, 1937, p. 157).

one image simply disappearing, it seems to jump across the intervening space into the other image. The latter becomes more distinct according to the extent to which it was being replaced by the background when the eye was occluded. For me, this phenomenon invariably occurs when the object is some distance in front of its background. When the object is very small and directly on a uniform background (a small dot on a white piece of paper) the movement may not occur or may not extend across the entire space. The reverse of this phenomenon may be produced by uncovering one eye or suddenly dropping a prism before one eye while both eyes are open. A second object then appears suddenly to emerge from the test object and jump across space to a new position. Wertheimer's explanation, referred to later, seems to be entirely inadequate for these types of contraocular Phi. I have been unable to produce such phenomena monocularly.

Five years ago it occurred to me that by suitably subjecting squinters to the conditions of the Phi phenomenon, additional light might be thrown not only on this phenomenon but also on the binocular vision of such persons. As I have elsewhere pointed out,[4] almost all, if not all, persons with established concomitant strabismus have anomalous projection. I demonstrated the fact that in this type of projection there is not, as is generally believed, abnormal retinal correspondence but absence of fixed retinal correspondence of any kind. The most striking feature of anomalous projection is that two images, one on each fovea, can be simultaneously and completely seen separated laterally in space. In the case of persons with normal binocular vision such perception is impossible. It seemed, therefore, that it would be desirable to ascertain in the case of a squinter whether or not the Phi phenomenon could be elicited by presenting a stimulus to one fovea and then to the other fovea. Accordingly, as opportunities presented, I have tested in this way 13 persons with strabismus, 10 with the convergent type and 3 with the divergent type.

Of the 10 patients with convergent strabismus, the youngest was aged 13 and the oldest 35. As determined by the cover test, the strabismus for distant vision varied from 10 prism diopters for the person with the least marked involvement to 35 prism diopters for the person with the most marked involvement. In each case the refraction was hypermetropic, and the corrected vision of the nonsquinting eye was 20/20 or better. The vision of the squinting eye was 20/20 or better in 6 cases, 20/30 in 1 case and 20/40 in 3 cases. Five of the patients had been operated on for convergent strabismus. The ages of the 3 patients with divergent strabismus were 14, 18 and 26 years. Two of

4. Verhoeff, F. H.: Anomalous Projection and Other Visual Phenomena Associated with Strabismus, Arch. Ophth. **19**:663 (May) 1938.

the patients were myopic and 1 was hypermetropic about 4 D. The corrected vision of the nonsquinting eye was 20/30 + for 1 patient and 20/20 for 2 patients. Two of the patients had been operated on for divergent strabismus.

The apparatus employed was exceedingly simple, yet adequate for the desired purpose. It consisted of an adjustable table, 60 by 38 cm., on which were placed two targets and suitable black screens. Each target consisted of a black cylinder 2.5 cm. in diameter and 8 cm. high, on the side of which was a round hole 6 mm. in diameter. On the inside the hole was covered with white translucent paper. Behind the hole was a small 2.2 volt Eveready Mazda lamp. The two lamps were wired to a dry cell battery in such a way that by means of a switch they could be alternately illuminated at any time interval desired. The screens were each 2.5 cm. wide. The positions of the targets and screens could be readily adjusted as desired, both vertically and laterally. The general illumination of the room was reduced sufficiently for a normal person readily to obtain the Phi phenomenon with the holes and a time interval of about one twentieth of a second. The targets were placed at a distance of about 60 cm. from the eyes. The squinter was instructed to fixate one target with one eye, and the other target was then so placed that its image occupied the fovea of the other eye, as determined by the cover test. The screens were then so placed as to exclude the extrafoveal images of the targets.

The Phi phenomenon was readily elicited in all 13 squinters, in some at once and in others after a few preliminary trials. The extent of the apparent movement closely corresponded to the actual distance between the targets. With the screens removed and the test made monocularly, it is interesting to note that the phenomenon could not be elicited in 2 persons after a considerable number of trials, in 1 person even when the distance between the targets was reduced.

A modification of the test was also employed for the persons with convergent squint. A white screen with a central hole 12 mm. in diameter was placed at the "crossing point" of the eyes while the patient was accommodating for the plane of the screen. The targets, still at a distance of 60 cm., were so placed that one could be seen through the hole with the right eye only and the other with the left eye only. Under these conditions, when the targets were alternately illuminated the light appeared to move not the actual distance between the targets, as in the previous test, but within the narrow limits of the hole. For 2 persons the adjustment happened to be so exact that a light appeared to go off and then come on in the same place within the hole, as if the patient had normal binocular fixation.

Certain persons with divergent strabismus have the ability to overcome the squint, that is to say, to fixate binocularly at will, although while

squinting they have anomalous projection. With 1 such person, included in the foregoing 13 patients, a boy aged 14 with exophoria of 25 prism diopters who could readily bifixate or squint at command, I made the following significant experiment: A vertical rod was placed in the midline 60 cm. from the eyes. While the left eye was fixating the rod and the other diverging, one target (A) was placed about 8 prism diopters and the other (B) about 16 prism diopters to the left of the rod; screens were so placed that A was seen with the left eye only and B with the right eye only. Under these conditions Phi was easily elicited. When first A was illuminated and then B, the hole appeared to move toward the right. The subject then bifixated the rod, B was placed 8 prism diopters to the left of the rod, and the screens were suitably readjusted. Again Phi was easily elicited. But now when first A was illuminated and then B, the hole appeared to move toward the left. It is to be noted that in both instances the same two retinal areas were stimulated and in the same sequence, yet in one instance (when the subject was squinting) the apparent movement was toward the right and in the other instance (when the subject was bifixating) toward the left. It is also to be noted that in each instance the external criteria were correctly interpreted in the sense that the direction of apparent movement corresponded to that of a real movement from A to B.

What significance can be attached to these experiments?

In regard to the vision of squinters, the experiments clearly accord with my previous observations that such persons do not, as commonly assumed, completely suppress the vision of the squinting eye but habitually employ a peculiar type of binocular vision without binocular fixation of any kind.

In regard to an explanation of the Phi phenomenon, these experiments show that this problem is even more complex than has been supposed. Wertheimer advanced the theory that the phenomenon was due to the meeting of excitations radiating from two cortical points which corresponded to the retinal points concerned. Phi resulted when, owing either to difference in the time between the excitations of the two cortical points or to difference in intensities of the excitations, the meeting point of the radiations was nearer to one point of excitation than to the other.

To accord with Wertheimer's theory, the foregoing experiments necessitate not only the assumption that in the case of a squinter manifesting anomalous projection the cortical representations of the two retinas must have locations essentially different from those of a person with normal binocular vision but also the assumption that even in the same individual squinter these representations must vary in location under different conditions. These assumptions obviously rob the theory of its simplicity and also render it highly improbable in its present form.

Since these experiments show that with the same contraocular retinal areas stimulated in the same sequence, Phi movements can be produced in opposite directions or a wide movement completely abolished, it follows that whatever may be the physiologic mechanism responsible for contraocular Phi this mechanism involves cortical points which do not bear fixed functional relation to the retinas. It would seem that with the present knowledge the only explanation, if such it can be termed, that can be given for the Phi phenomenon is that actual motion and the external conditions which cause Phi produce in the brain conditions so closely similar that they are interpreted in the same way.

CONCLUSIONS

The Phi phenomenon can be elicited by alternate stimulation of the two foveas of squinters with good visual acuity in each eye, who are manifesting anomalous projection.

In the case of a person with convergent squint, who without binocular fixation is projecting his foveal images to the "crossing point" of his eyes, Phi movement of the images is greatly reduced or completely abolished.

These observations accord with the fact that both eyes, and particularly the two foveas, are habitually employed simultaneously by squinters who are free from amblyopia.

In the case of a squinter conditions can be produced so that with alternate stimulation of the same two contraocular retinal areas the direction of Phi movement when the subject is squinting is opposite to that when he is fixating binocularly.

In its present form, Wertheimer's explanation of the Phi phenomenon is highly improbable.

The physiologic mechanism responsible for the contraocular Phi involves cortical points which do not bear fixed functional relation to the retinas.

CLINICOPATHOLOGIC STUDY OF DIABETIC RETINITIS

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It has been accepted for many years that the occurrence of diabetic retinitis is based on associated arteriosclerosis, whether hypertensive or nonhypertensive. Yet the ophthalmologist is able to identify this condition in a large percentage of cases as a definite clinical entity. Extensive clinical experience has brought out certain points in differential diagnosis which, though useful in practical application, lack force, because no satisfactory pathologic explanation has been offered.

In ophthalmoscopic study of diabetic persons one cannot fail to note the frequency of hemorrhages, sometimes petechial and sometimes massive. Large hemorrhages are usually preceded by engorgement and irregularity of caliber of retinal veins, with a tendency to thrombosis. These signs may be seen in the absence of arteriosclerosis or out of proportion to severity of arteriolar hypertensive disease and, furthermore, in spite of normal renal function.

It would appear that while the presence of hyperglycemia may be responsible for metabolic changes in arterial walls, the effect is even more specific on capillaries and veins. The inference that small hemorrhages are caused by the breaking down of capillaries while large hemorrhages are caused by thrombosis of retinal veins seems inevitable.

Since it is obvious that tendency to hemorrhage is the basis of diabetic retinitis and that all other changes are secondary, one does not have to go beyond the venocapillary system for solution of pathogenesis.

In order to expose the venous and capillary pathologic picture, it was important to obtain longitudinal sections of veins and to make tangential and oblique sections through the several layers of the retina. By this method, vessel walls could easily be studied, and capillary networks stood out in relief. To facilitate the use of this technic, the retina was cut up into small pieces, 2 or 3 mm. in diameter. Animal and normal retinas were used as controls.

In studying the retinas of patients taken at random, evidence of sclerosis of retinal arteries was found in many instances. Sclerosis of the veins, however (although present in moderate degree in cases of nonhypertensive sclerosis as well as in cases of advanced hypertension and nephritis), was most marked in cases of diabetes. Capillary changes, while present in sections from patients with advanced nephritis, showed the greatest disintegration in retinas of diabetic persons.

STUDY OF PATHOLOGIC SECTIONS

Veins.—In studying the venules of 25 retinas, fibrosis of the intima was found in 9 (fig. 1). In 8 others the media showed separation of longitudinally directed collagen fibrils, creating an unraveling effect of the media (fig. 2). Some of the fibrils appeared hyalinized. In a few of the retinas some of the postcapillary venules showed complete hya-

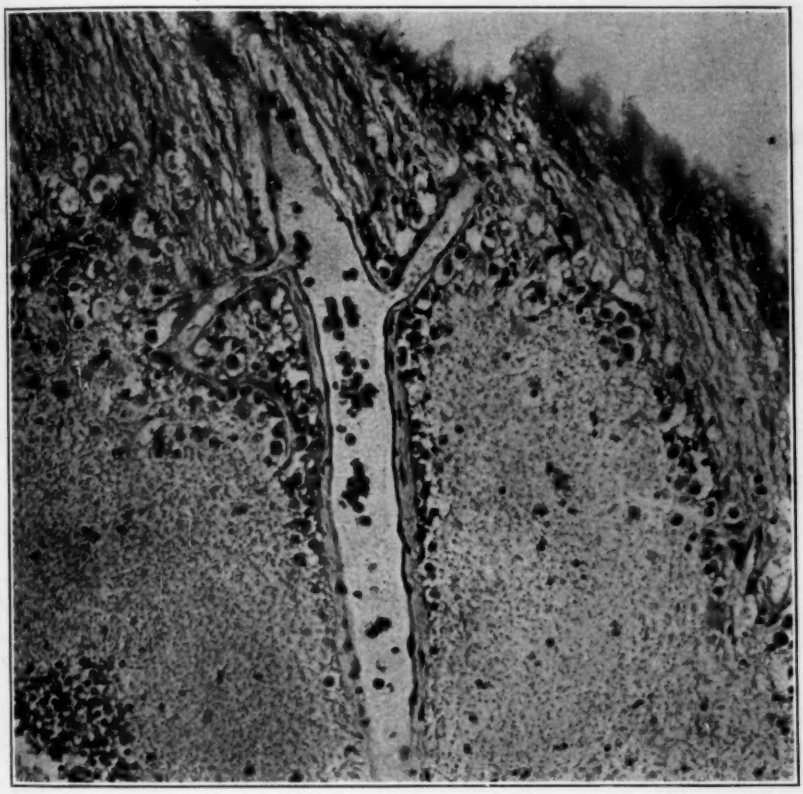

Fig. 1.—Section of retina showing a large retinal venule with thickened endothelium and capillaries in the ganglion cell and internal nuclear layers; × 375. The retina was taken from a man aged 76. The anatomic diagnosis in this case was carcinoma of the esophagus, generalized atherosclerosis, coronary occlusion and brown atrophy of the liver.

linization, with no line of demarcation between the intima and the media and an appreciable decrease in nuclear elements. In 2 retinas there was thickening of media due to deposit of collagen. Of 9 showing advanced venular pathologic changes, 8 were from patients also showing

generalized atherosclerosis, 2 from patients with hypertensive diabetes and 3 from patients with severe diabetes without hypertension.

Capillaries.—In the sections studied capillary networks stood out most prominently in the internal nuclear layer. In addition to this, hemorrhages and exudates were found most frequently near the capillaries and far from larger vessels (fig. 3).

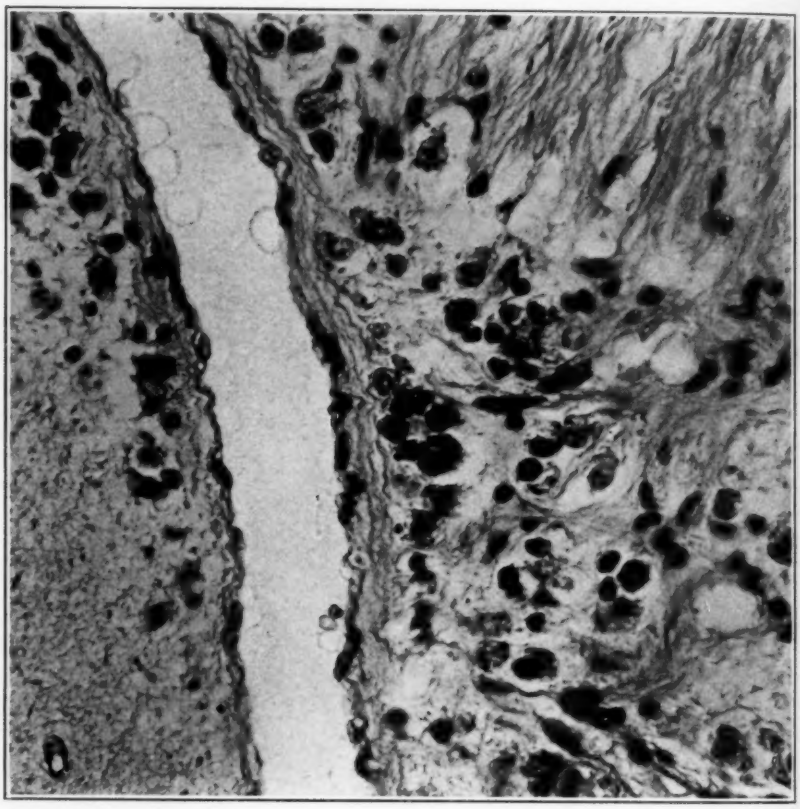

Fig. 2.—Section of retina showing a venule with patchy fibrosis of the intima; × 375. The media shows an unraveling effect with occasional patches of hyaline. The retina was taken from a woman aged 60 with mild diabetes. The anatomic diagnosis in this case was chronic glomerulonephritis and generalized atherosclerosis.

Normal retinal capillary loops and networks, unless filled with corpuscles, collapsed and were difficult to identify. The open capillaries had parallel walls, which consisted of thin collagenous or reticular fibers; endothelial cell and Rouget cell nuclei were seen at regular intervals. These sometimes appeared directly over the lumen (fig. 4).

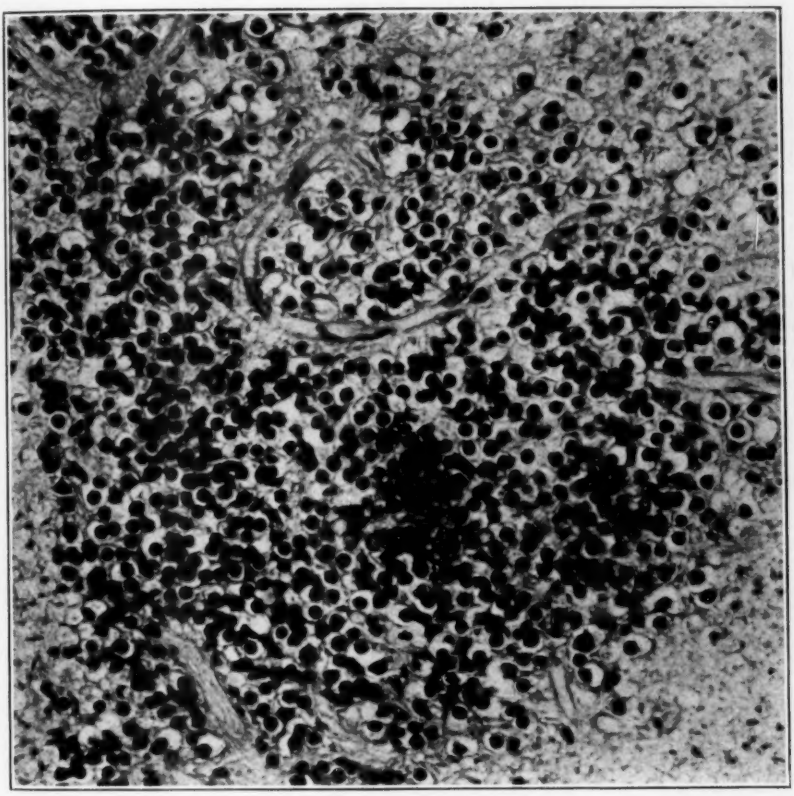

Fig. 3.—Section through the internal nuclear layer of a retina. The capillary walls are indistinct, fading out in some places. Fresh hemorrhages are evident. The retina was taken from a man aged 47. The anatomic diagnosis in this case was diabetes, chronic glomerular nephritis, pulmonary tuberculosis and generalized atherosclerosis.

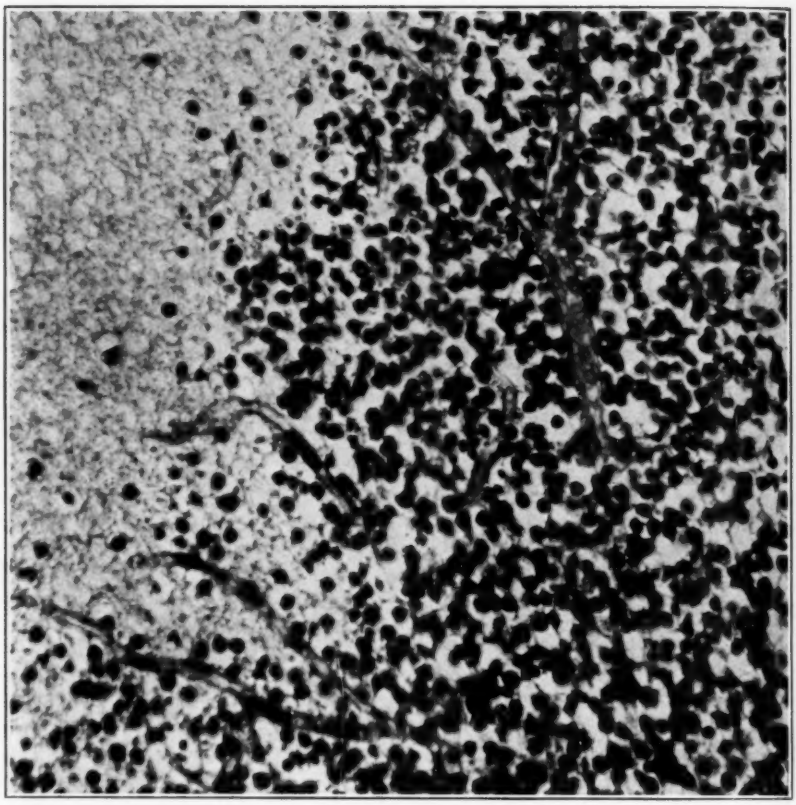

Fig. 4.—Section of retina showing normal precapillaries and capillaries; × 375. The endothelial cells and Rouget cells are seen at intervals. The dilated lumen is filled with blood elements and there are thin parallel walls. The retina was taken from a girl 17 years old, who died of chronic rheumatic heart disease of five years' duration. The fundi were normal.

Diseased retinal capillary loops and networks stood out because of their rigid patency, dilated lumens and thickened walls (fig. 5). The lumens, though dilated, were usually empty. The walls were irregular and seldom parallel, and some of the segments appeared indistinct and sometimes invisible. Endothelial and Rouget cell nuclei sometimes showed chromatolysis, karyorrhexis or pyknosis. Abnormal capillaries showed some or all of these changes in varying degree. Fresh hemor-

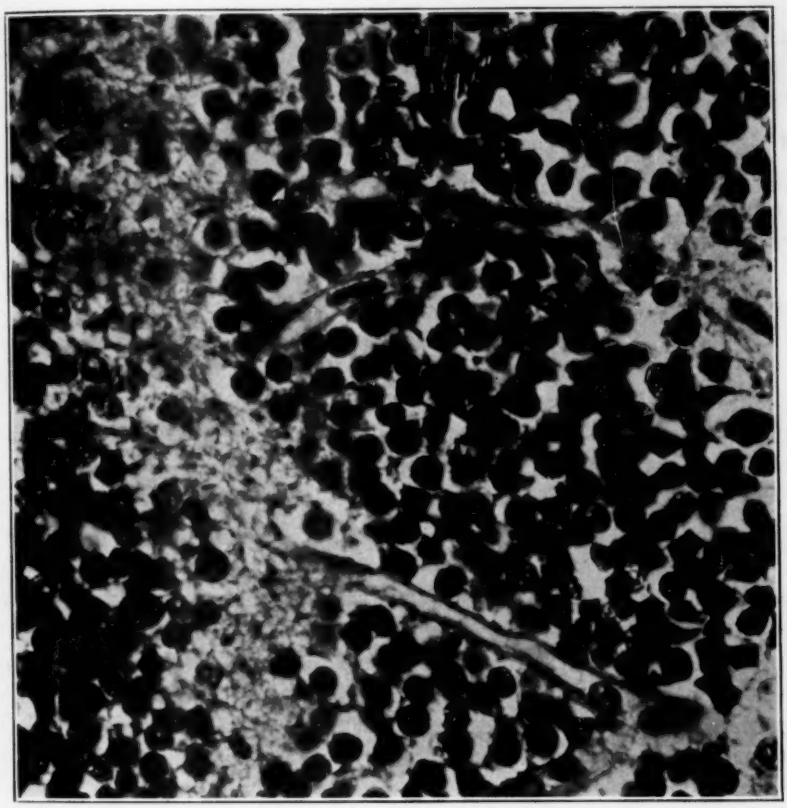

Fig. 5.—Section of retina showing thickened capillary walls, empty lumen and absence of endothelial cells; × 375. The retina was taken from a woman aged 70, who had mild diabetes with generalized atherosclerosis and chronic cholecystitis. The anatomic diagnosis also included chronic pulmonary tuberculosis, tuberculous empyema and nephritic abscesses.

rhages could be seen most frequently in sections in which the capillaries showed severe change.

This is a preliminary report of work still in progress. The pathologic sections were prepared by Dr. Howard J. Agatston in the pathologic laboratory of the Montefiore Hospital.

INSTRUMENTS AND TECHNICS FOR THE CLINICAL TESTING OF LIGHT SENSE

IV. SIZE OF PUPIL AS A VARIABLE FACTOR IN THE DETERMINATION OF THE LIGHT MINIMUM

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It is generally recognized that with other factors constant the intensity of light incident on the retina varies with the size of the pupil and that consequently determinations of the sensitivity of the eye to light are influenced by the size of the subject's pupil. Opinions differ, however, both as to the proper method of controlling or correcting for this variable factor and as to the practical necessity for so doing in clinical studies of light sense.

Troland [1] in 1917 suggested the employment of a special unit of retinal brightness called the "photon," defined by him as "that intensity of stimulation which accompanies the use of a pupillary area of one square millimeter and an external stimulus surface brightness of one candle per square meter." In order to obtain the photon value of any given stimulus, the external brightness in millilamberts is multiplied by $\frac{10}{\pi}$ times the area of the entrance pupil in square millimeters. The use of the photon as a unit of retinal illumination involves the assumption that the brightness of the retinal image is proportional to the area of the entrance pupil.

Recent studies by Stiles and Crawford and others indicate that this assumption may not be valid for all experimental conditions. In the experiments reported by Stiles and Crawford in 1933 [2] it was shown that the apparent luminous efficiency of rays of light passing through the peripheral portions of the pupil is less than that of rays passing through the more central portions. As a result, the effective area of the pupil

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1. Troland, L. T.: The Measurement of Visual Stimulation Intensities, J. Exper. Psychol. **2**:24-32, 1917.

2. Stiles, W. S., and Crawford, B. H.: The Luminous Efficiency of Rays Entering the Eye Pupil at Different Points, Proc. Roy. Soc., London, s.B **112**:428-450, 1933.

increases less rapidly than does the actual area. In the first measurements of this phenomenon reported in 1933 by Stiles and Crawford the relative luminous efficiencies of the different pupillary zones were determined by means of photometric matches. The method of flicker photometry was used. The measurements were made with foveal vision and with fairly high field brightnesses. Further studies confirming the existence of the phenomenon were reported in 1934 by Dziobek [3] and in 1936 by Wright and Nelson.[4] The experimental conditions were similar to those of Stiles and Crawford, except that the photometric matches were made by the "equality-of-brightness" instead of by the flicker method of photometry. In these three investigations white light stimuli were used. In a later study Stiles [5] repeated the experiments with monochromatic lights from a series of different regions of the spectrum. He found that the decrease in apparent luminous efficiency from the center to the periphery of the pupil was greatest for blue light, intermediate for red and least for yellow-green. Goodeve [6] in 1936 showed that the phenomenon could also be demonstrated in measurements of the foveal threshold for red light.

Wright and Nelson suggested as an explanation of the Stiles-Crawford phenomenon that the retina might have a fundamental directional sensitivity and that the cones may respond only to light striking them perpendicularly. Later studies by Crawford [7] in 1937 lend support to the view that the phenomenon is retinal in origin rather than the result of a greater absorption of the peripheral rays in passing through the optical media of the eye. In these experiments the relative efficiencies of the different pupillary zones were computed from threshold determinations rather than from photometric matches. With a general field brightness of *22* candles per square foot, the determinations of relative efficiency by means of threshold measurements at the fovea gave results in close agreement with the previous data. Similar measurements were then made for regions of the retina more or less distant from the fovea and for field brightness ranging from *22* candles per square foot down to

3. Dziobek, W.: Der Stiles-Crawford Effekt und seine Bedeutung für die Photometrie, Licht **4**:150-152, 1934.

4. Wright, W. D., and Nelson, J. H.: The Relation Between the Apparent Intensity of a Beam of Light and the Angle at Which the Beam Strikes the Retina, Proc. Phys. Soc. London **48**:401-405, 1936.

5. Stiles, W. S.: The Luminous Efficiency of Monochromatic Rays Entering the Eye Pupil at Different Points and a New Color Effect, Proc. Roy. Soc., London, s.B **123**:90-118, 1937.

6. Goodeve, C. F.: Relative Luminosity in the Extreme Red, Proc. Roy. Soc., London, s.A **155**:664-683, 1936.

7. Crawford, B. H.: The Luminous Efficiency of Light Entering the Eye Pupil at Different Points and Its Relation to Brightness Threshold Measurements, Proc. Roy. Soc., London, s.B **124**:81-96, 1937.

zero. "In the latter condition," Crawford pointed out, "no stimulus is applied to the eye except the test spot and a dim fixation spot, and the condition of the eye can therefore approach closely to that of complete dark adaptation." With foveal stimulation, the curve showing the decrease in efficiency from the center to the periphery of the pupil shows no significant change with change from high to zero field brightness. With parafoveal stimulation, however, the results are different. With the higher field brightnesses, the curves resemble those for the fovea, but with decreasing field brightness the curves flatten out. Those for zero field brightness are almost flat, indicating that under this condition the luminous efficiency of a light pencil is practically independent of its point of entry through the pupil of the eye. Consequently, the brightness of the retinal image is approximately proportional to the area of the pupil, as was previously believed to be true under all conditions. Crawford suggested as an explanation for these findings that the apparent increase in efficiency of the peripheral zones of the pupil with dark adaptation might be due to migration of pigment away from the recipient elements. The next section of Crawford's paper reports a study of the change in luminous efficiency with time after a high brightness is suddenly cut off. The results indicate that after about five minutes of dark adaptation the thresholds are approximately the same for light pencils passing through the center and through the periphery of the pupil.

The results of these various investigations may be summarized as follows: Under certain experimental conditions the peripheral zones of the pupil show an apparent decrease in luminous efficiency. As a result, the brightness response of the eye is not directly proportional to the area of the entrance pupil. Under other experimental conditions the different pupillary zones show an apparently equal luminous efficiency, and the brightness response of the eye is therefore directly proportional to the area of the entrance pupil.

1. The brightness response is *not* proportional to the area of pupil *(a)* when photometric matches are made at high intensity with white light, either by flicker photometry (Stiles and Crawford) or by "equality-of-brightness" photometry (Dziobek, Wright and Nelson), *(b)* when threshold determinations are made at the fovea either with white light (Crawford) or with red light (Goodeve) or *(c)* when photometric matches are made at high intensity with monochromatic light stimuli (Stiles).

2. When threshold determinations are made in paracentral regions of the retina, the apparent pupillary efficiency depends on the brightness of the surrounding field and the state of adaptation of the eye (Crawford). *(a)* When the brightness of the surrounding field is high, a decreased efficiency of the peripheral zones of the pupil is observed.

(b) When the brightness of the surrounding field is zero and the eye is partially or completely dark adapted, *no* decrease in efficiency in the peripheral zones is observed. Under these conditions, therefore, the brightness response of the eye is directly proportional to the area of the pupil.

In general, the results suggest that under experimental conditions in which the brightness response is mediated chiefly by rods, the luminous efficiency of the stimulus is directly proportional to the area of the pupil. Under conditions in which the response is mediated chiefly by cones, however, the increase in luminous efficiency lags behind the increase in area of the pupil.

In the various clinical investigations of the light sense of the eye, several different methods have been employed to eliminate or to correct for differences in size of pupils. In some studies a small artificial pupil has been used, obtained by means of an actual aperture placed in front of the cornea. Limitation of the effective entrance pupil has also been achieved by focusing the incident light into a small image in the plane of the pupil. Troland [8] has shown that an actual aperture in front of the eye cannot be used in testing the far periphery of the retina. Waite, Derby and Kirk [9] rejected both of these methods because of their unsuitability for use with clinic patients. Both require an exact alinement of the eye in relation to the testing apparatus and therefore require considerable cooperation on the part of the patient. Measurement of the diameter of the pupil by photography was also considered unsatisfactory by Waite and his associates because some persons have a black pigment border to the iris which may be indistinguishable in a photograph from the pupil itself. In the method finally adopted by these investigators, pilocarpine was used to fix the pupil to light. The diameter of the entrance pupil was then measured with the corneal microscope, and a correction factor applied to the threshold measurements. Others have used a mydriatic to fix the pupil to light.

There are three possible objections to this method of correcting for differences in size of pupil. 1. The drug used must be known not to have an effect on the sensitivity of the retina. It is conceivable, for example, that early defects in light sense in patients with incipient glaucoma might be more easily detected if pilocarpine were not instilled immediately before the test. 2. When a mydriatic or a miotic is used to fix the pupil to light, the amounts of dilatation or contraction are not

8. Troland, L. T.: The Theory and Practice of the Artificial Pupil, Psychol. Rev. **22**:167-176, 1915.

9. Waite, J. H.; Derby, G. S., and Kirk, E. B.: The Light-Sense in Early Glaucoma, Particularly the Achromatic Scotopic Threshold at the Macula: A Preliminary Report, Tr. Ophth. Soc. U. Kingdom **45**:301-331, 1925.

the same for the different persons, and the effective brightness of the preadapting field therefore varies from subject to subject. This variation in level of previous light adaptation has some effect on the earlier portions of the curve of dark adaptation but no effect on the final threshold after dark adaptation is complete. 3. In correcting the measurements of retinal response for differences in size of pupil, Waite, Derby and Kirk and others who have followed this procedure assumed that retinal illumination is directly proportional to area of pupil. The recent studies of Stiles and Crawford previously described indicate, however, that a more complex relation between area of pupil and the stimulating power of the light may perhaps exist. In the present state of knowledge with regard to this apparently complex phenomenon, it would appear desirable that the luminous efficiency factors for different pupillary areas be determined for the particular experimental conditions under which the measurements of the light sense are to be made, before any corrections are applied for area of pupil.

Others who have devised procedures for the clinical testing of light sense find that the individual differences in sensitivity to light of normal persons and the daily variations in sensitivity of a single person are of such magnitude that differences due to size of pupil are of little practical importance in diagnosing abnormalities in sensitivity to light. In a study reported by Hecht and Mandelbaum [10] in 1939 determinations were made of the curves of dark adaptation of 110 normal persons. The purpose of this study was to obtain norms for use in the diagnosis of vitamin A deficiency. In the group of normal subjects the highest and lowest values of the final rod threshold differed by 1.0 log unit. The maximum variation in successive tests of the same person was 0.3 log unit. These determinations were made with the natural pupil without correction. It is reasonable to suppose that in both the control group and in the subjects tested for vitamin A deficiency the pupils dilated normally in the dark. Differences in the light threshold due to differences in size of pupil would therefore be of small magnitude.

In clinical studies of the light minimum in various pathologic ocular conditions, however, the influence of size of pupil on the determinations cannot always be ignored. Patients with glaucoma who are using pilocarpine will have abnormally small pupils, whereas those who have had an iridectomy may have abnormally large pupils. In studying the effects of tabetic atrophy of the optic nerve on the light sense, the Argyll Robertson phenomenon must be taken into account, because the Argyll Robertson pupil will as a rule be appreciably smaller in the dark than the normal pupil. A decrease in pupillary diameter from 6 to 2 mm.,

10. Hecht, S., and Mandelbaum, J.: The Relation Between Vitamin A and Dark Adaptation, J. A. M. A. **112**:1910-1916 (May 13) 1939.

assuming the threshold to vary inversely with the area of pupil, will cause an increase in threshold of 0.95 log units. It is obviously desirable, therefore, in certain types of clinical studies of light sensitivity to be able to eliminate this variable factor by applying a correction to the threshold measurements.

Crawford's studies suggest that although under many conditions of observation the apparent retinal brightness is not directly proportional to area of pupil as was previously believed to be the case, the older view may be approximately correct for parafoveal or peripheral vision in the dark-adapted eye. If this is true, it is possible to correct measurements of the light minimum or achromatic threshold for differences in size of pupil without applying any additional correction for variation in luminous efficiency. Crawford's findings, however, suggest that such a correction will be required when measurements of the light minimum are made at the fovea.

PRESENT INVESTIGATION

One of the purposes of the present study was to investigate the Stiles-Crawford phenomenon under experimental conditions which are directly applicable to threshold determinations and in particular to the measurements obtained with the perimetric light sense tester described in an earlier paper in this series.[11] Most of the previously published data on the Stiles-Crawford phenomenon are expressed in terms of the change in luminous efficiency of a small light pencil when it is made to pass through different zones of the pupil. The data are therefore not given directly in a form which shows the magnitude of the effect for the pupil as a whole or which permits of an estimation of its significance in determinations of the threshold of the dark-adapted eye.

The first group of experiments consisted in determinations by 3 subjects of the light minimum of the dark-adapted eye, with the natural pupil dilated by means of euphthalmine and with a series of artificial pupils ranging from 5.13 to 1.02 mm. in diameter. The diameter of the natural pupil was determined by photography. The test field was located on the perimeter arc 6 degrees from the fixation point in the nasal field. The luminous red fixation device described in a previous paper [12] was used to maintain foveal fixation. This fixation device contains an illuminated target and a convex lens. By adjusting the distance of the target from

11. Sloan, L. L.: Instruments and Technics for the Clinical Testing of Light Sense: III. An Apparatus for Studying Regional Differences in Light Sense, Arch. Ophth. **22**:233-251 (Aug.) 1939.

12. Sloan, L. L.: Instruments and Technics for the Clinical Testing of Light Sense: II. Control of Fixation in the Dark-Adapted Eye, Arch. Ophth. **22**:228-232 (Aug.) 1939.

the lens, the virtual image of the target may be located at the far point of the subject's eye, so that it is seen clearly with relaxed accommodation. The fixation device is inserted in the hollow axle of the perimeter arc, so that the red target is seen by the subject through the round hole in the center of the arc.

In order to insure that the artificial pupil is centered approximately on the visual axis, the following device was employed in these experiments: The round opening in the perimeter arc was outlined with a narrow ring of radium paint. Since the fixation target is farther from the eye than the luminous ring, each point of light from the latter will form a blur circle on the retina the location of which depends on the position of the artificial pupil in relation to the visual axis. When the

TABLE 1.—*Thresholds of Subject A for a 1 Degree White Test Object at 6 Degrees in the Nasal Field, Determined with the Perimetric Light Sense Tester**

Diameter of Pupil in Mm.	Log A A = Area of Pupil in Sq. Mm.	Log T T = Threshold or Light Minimum in Lamberts $\times 10^{-12}$	Log [AT] = Log A + Log T K = Average Value of Log [AT]	Log E = K − Log [AT] E = Efficiency Factor of Pupil
7.24 †	1.6045	3.5250	5.1295	−0.0709
5.13	1.3153	3.7250	5.0403	+0.0183
4.07	1.1143	3.9250	5.0393	+0.0193
2.95	0.8347	4.2125	5.0472	+0.0094
2.61	0.7283	4.3375	5.0658	−0.0072
1.99	0.4929	4.6625	5.1554	−0.0968
1.35	0.1557	4.8000	4.9557	+0.1029
1.17	0.0315	4.9750	5.0065	+0.0521
1.02	−0.0877	5.1750	5.0873	−0.0287
			K = 5.059	

* Taken May 18, 1938.
† Natural pupil dilated with euphthalmine.

artificial pupil is centered on the visual axis, the red fixation target will appear in the center of the luminous ring. A shift in the location of the artificial pupil from this position will produce a shift in the relative location of the red fixation target and the circumscribed luminous ring.

The data for subject A are shown in table 1. Column 1 gives the pupillary diameters in millimeters, column 2 the areas in square millimeters and column 3 the corresponding values of the threshold. The data in columns 2 and 3 are given in logarithmic units. If, as was found by Stiles and Crawford, light from the outer zones of the pupil is less effective than that from the more central regions, then the product, threshold times area of pupil, will not be a constant but will show a regular decrease with increase in area of pupil. If, however, the product, threshold times area, is a constant within the precision of the threshold determinations, then, since AT is a constant, log [AT], which equals log A + log T, is likewise a constant. In figure 1, curve A, the corres-

ponding values of log T and log A for subject A are plotted on the ordinate and abscissa, respectively. The equation for the straight line drawn through the experimentally determined points is log A + log T = 5.059. Inspection of the curve shows that the experimentally determined

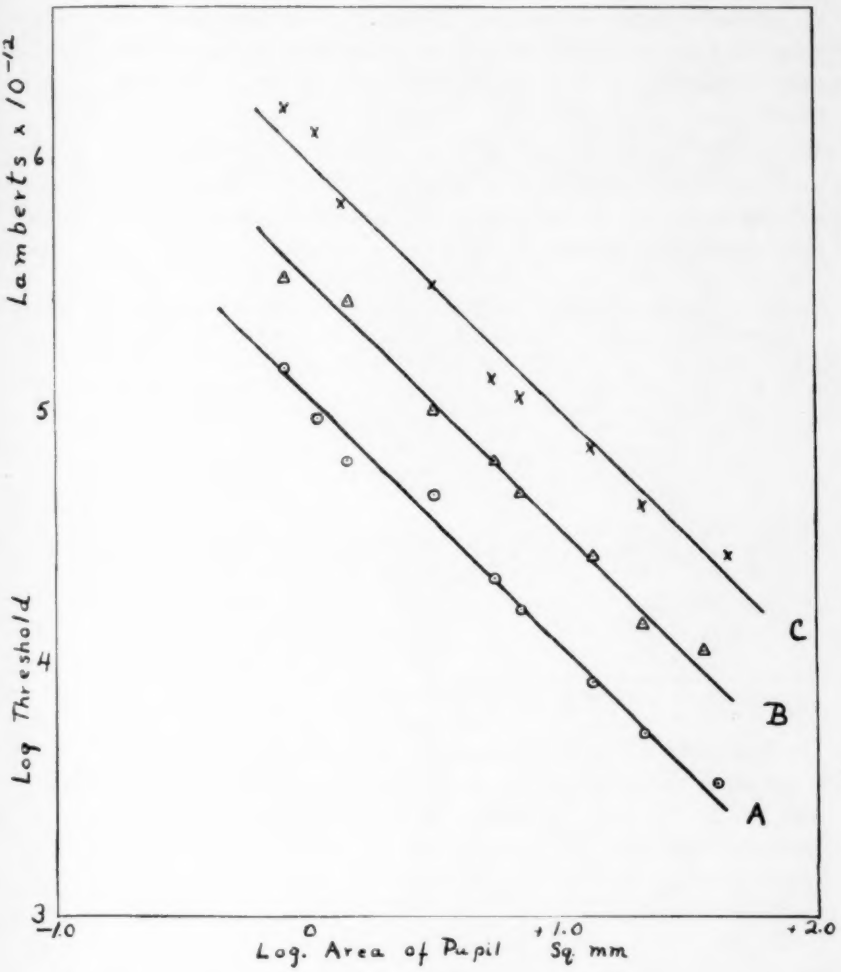

Fig. 1.—Thresholds of three subjects for 1 degree white test object at 6 degrees in the nasal field, determined with the perimetric light sense tester. The curves for subjects B and C have been shifted upward on the ordinate scale by 0.2 and 1.0 log unit, respectively.

values of log T lie approximately on the straight line, and the deviations are in no case greater than would be expected from the normal variation in successive determinations of the threshold. The magnitude of the

deviations is also shown in table I. Column 4 gives the successive values of log A + log T or log [AT]. The average value is 5.059. The deviations from the average, log E = 5.059 — log [AT], are given in column 5. A negative value for log E indicates that the experimentally determined value of the threshold is greater than the theoretic value and that the efficiency factor for this size of pupil is less than unity. A positive value of log E, conversely, indicates an efficiency factor greater than unity. When log E = O, the efficiency factor is unity. As may be seen, there is no regular decrease in efficiency with increase in area of pupil but merely slight positive or negative variations from zero. These variations from the theoretic zero are less than 0.1 log unit in every case and can therefore be attributed to the normal variation to be expected in successive determinations of log T.

TABLE 2.—*Thresholds of Subjects B and C for a 1 Degree White Test Object at 6 Degrees in the Nasal Field, Determined with the Perimetric Light Sense Tester*

Subject B			Subject C		
D	Log [AT]	Log E	D	Log [AT]	Log E
6.72 †	5.3998	—0.0794	7.38 ‡	5.0562	—0.0669
5.13	5.2753	+0.0451	5.13	4.9403	+0.0490
4.07	5.3393	—0.0189	4.07	4.9643	+0.0250
2.95	5.3097	+0.0207	2.95	4.8847	+0.1046
2.61	5.3283	—0.0079	2.61	4.8533	+0.1360
1.99	5.2929	+0.0275	1.99	4.9929	—0.0036
1.35	5.3807	—0.0603	1.35	4.9682	+0.0211
			1.17	5.1315	—0.1422
1.02	5.2373	+0.0831	1.02	5.1123	—0.1230
	K = 5.3204			K = 4.9893	

† Natural pupil dilated with homatropine.
‡ Natural pupil dilated with euphthalmine.

The results of similar determinations for subjects B and C are shown in curves *B* and *C* of figure 1. The corresponding data are given in table 2. In the case of subject B the deviations of log T from the theoretic values are less than ± 0.08 in every case. The results for subject C show a slightly greater variation. The largest values of log E are + 0.14 for a pupil of 2.61 mm. and — 0.14 for a pupil of 1.17 mm. These data, however, show no evidence of a regular decrease in efficiency with increase in area of pupil. Similar determinations were also made by subject A with the Hecht adaptometer. Figure 2 shows these data (curve 1) and for comparison the corresponding data for two independent tests in which the thresholds were determined with the perimetric light sense tester (curves 2 and 3). The data for curves 1 and 3 are given in table 3. Curve 2 is the same as curve *A* in figure 1. The tabular data for this curve have already been given in table 1. The measurements of the threshold made with the two instruments were

obtained under the same experimental conditions, i.e., with a 1 degree white test field located 6 degrees from the fixation point in the nasal field. Although the thresholds determined with the Hecht adaptometer show a slightly greater variation from the theoretic curve, there is no evidence of any regular decrease in apparent efficiency with increase in area of pupil.

With Hecht's standard procedure for studying dark adaptation, the threshold determinations are made with a test field subtending a visual

TABLE 3.—*Comparison of Thresholds of Subject A for a 1 Degree White Test Object at 6 Degrees in the Nasal Field as Determined with the Light Sense Tester and the Hecht Adaptometer*

	Perimetric Light Sense Tester 5/4/38		Hecht Adaptometer	
D	Log [AT]	Log E	Log [AT]	Log E
5.13	5.2553	−0.0414	5.6873	−0.1365
4.07	5.1643	+0.0496	5.6043	−0.0535
2.95	5.1847	+0.0292	5.5637	−0.0129
2.61	.....	.....	5.6713	−0.1205
1.99	5.2229	−0.0090	5.4829	+0.0679
1.35	.....	.....	5.4907	+0.0601
1.02	5.2423	−0.0284	5.3553	+0.1955
	K = 5.2139		K = 5.5508	

TABLE 4.—*Thresholds of Subject A for Blue, Determined with the Hecht Adaptometer*

	1° Blue, at 7° in Temporal Field		3° Blue, at 7° in Temporal Field	
D	Log [AT]	Log E	Log [AT]	Log E
5.13	4.1563	+0.0865	3.8073	−0.0308
4.07	4.1698	+0.0735	3.7733	+0.0032
2.95	4.2967	−0.0539	3.7767	−0.0002
2.61	4.2523	−0.0095	3.8393	−0.0628
1.99	4.2989	−0.0561	3.7279	+0.0486
1.35	4.2857	−0.0429	3.7077	+0.0688
1.02	4.2403	+0.0025	3.8033	−0.0268
	K = 4.2428		K = 3.7765	

angle of 3 degrees, located 7 degrees from the fixation point in the temporal field. A blue filter is used in front of the light source, so that the determinations are made with light from the short wavelength end of the spectrum. Since Stiles has found that the magnitude of the Stiles-Crawford phenomenon varies when determinations are made with light from different regions of the spectrum, a third series of experiments were made in which the thresholds for different sizes of pupil were determined with blue light at 7 degrees in the temporal field. These data are shown in table 4 and figure 3. Curve 1 is for a test field subtending a visual angle of 1 degree and curve 2 for a field of 3 degrees, such as is used by Hecht. These determinations were also made by subject A. As in the

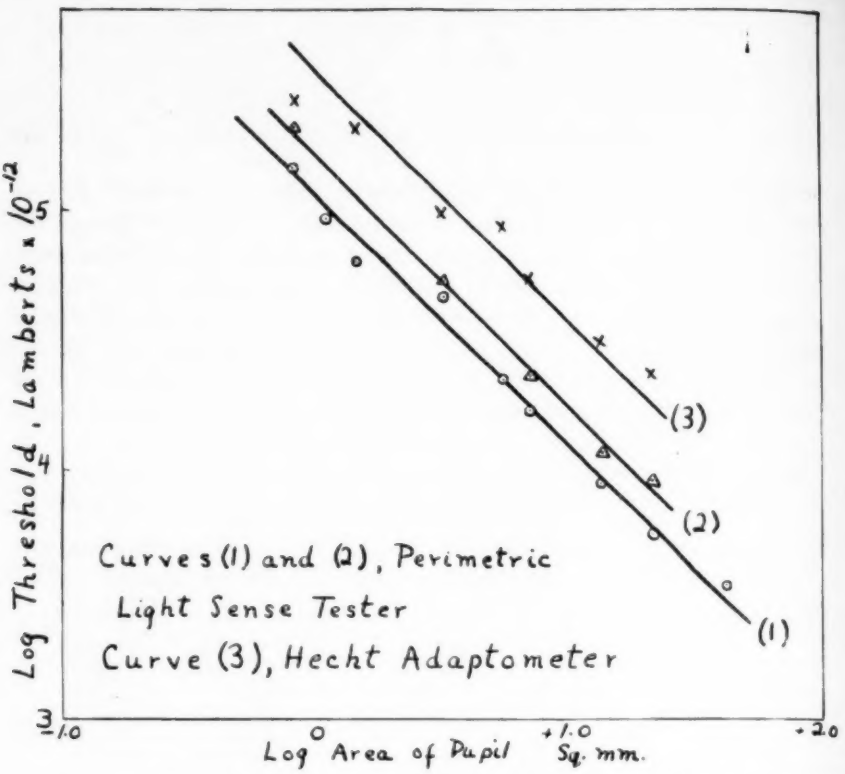

Fig. 2.—Thresholds for a 1 degree white test object at 6 degrees in the nasal field, determined by perimetric light sense tester and the Hecht adaptometer.

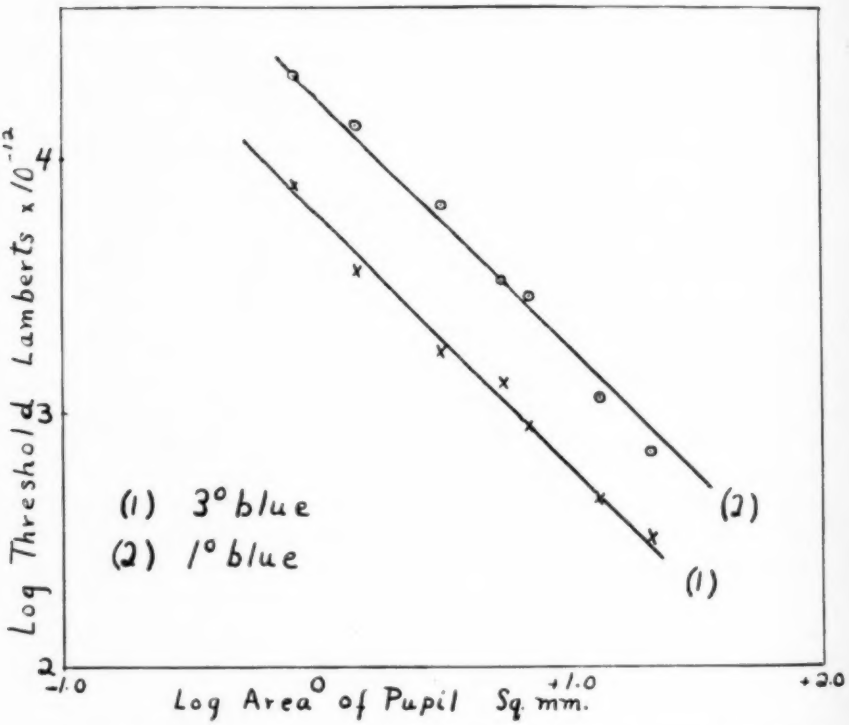

Fig. 3.—Thresholds for blue determined at 7 degrees in the temporal field with Hecht adaptometer.

previous experiments, the values of the threshold show no significant deviations from the theoretic curve based on the assumption that threshold times area is a constant.

The experiments so far reported are in accord with previous findings, since the conditions are those in which the Stiles-Crawford phenomenon was found *not* to occur. The conditions under which one should expect threshold determinations to be affected by this phenomenon are those in which the retinal response is mediated chiefly by cones. A final group of experiments were therefore made to test those particular experimental conditions in which threshold determinations would be expected to show some evidence of the phenomenon. On the basis of Goodeve's results, for example, the thresholds for red light should show an apparent decrease in efficiency with increase in pupillary area. From Crawford's studies one should also expect such an effect for white light stimuli when the tests are made at the fovea. And since Stiles found that the

TABLE 5.—*Foveal Thresholds of Subject A*

	1° White Perimetric Light Sense Tester		1° White Hecht Adaptometer		1° Blue Hecht Adaptometer		1° Red Hecht Adaptometer	
D	Log [AT]	Log E	Log [AT]	Log E	Log [AT]	Log E	Log [AT]	Log E
5.13	6.9503	+0.0056	6.8013	+0.1688	7.1493	−0.1320	6.4813	+0.1186
4.07	6.9643	−0.0084	7.0773	−0.1072	7.1073	−0.0900	6.5943	+0.0056
2.95	6.9097	+0.0462	6.9407	+0.0294	6.9917	+0.0256	6.6927	−0.0028
2.61	.....	.....	7.0243	−0.0542	7.0833	−0.0660	6.6953	−0.0054
1.99	6.9179	0.0380	7.0509	−0.0808	6.8929	+0.1244	6.6659	−0.0760
1.35	.....	.....	7.0707	−0.1006	6.9747	+0.0426	6.5877	+0.0122
1.02	7.0373	−0.0814	6.8253	+0.1448	6.9223	+0.0950	6.5723	+0.0276
	K = 6.9559		K = 6.9701		K = 7.0173		K = 6.5999	

phenomenon occurred throughout the entire spectrum, determinations with blue light, such as is used by Hecht, should also show an effect at the fovea.

Table 5 and figure 4 give data on the foveal thresholds for a 1 degree white, a 1 degree blue and a 1 degree red stimulus. The thresholds for a 1 degree white stimulus were measured both on the perimeter and on the Hecht adaptometer. The thresholds for red and blue were determined only with the latter instrument. The average value of log [AT] is 6.96 and 6.97, respectively, when measured on the perimeter and on the Hecht instrument. The foveal sensitivities as determined by the two instruments are therefore in close agreement. The average value of log [AT] for blue light is likewise essentially the same as that for white light. For red light, however, log [AT] is smaller, indicating that this subject's threshold for red is lower than for white or blue.

The values of log E given in table 5 show no evidence of any consistent decrease in apparent pupillary efficiency with increase in area. The thresholds for white, measured on the perimeter, and those for red,

measured on the Hecht adaptometer, show extremely small deviations from the theoretic values to be expected if threshold times area is a constant. The thresholds for blue and for white, measured on the Hecht instrument, show somewhat greater deviations, but in no case do the values of log T differ from the theoretic values by as much as 0.2. Variations of this magnitude in threshold measurements are of no practical significance, since Hecht has found with his instrument a day-to-day variation of 0.3 log unit.

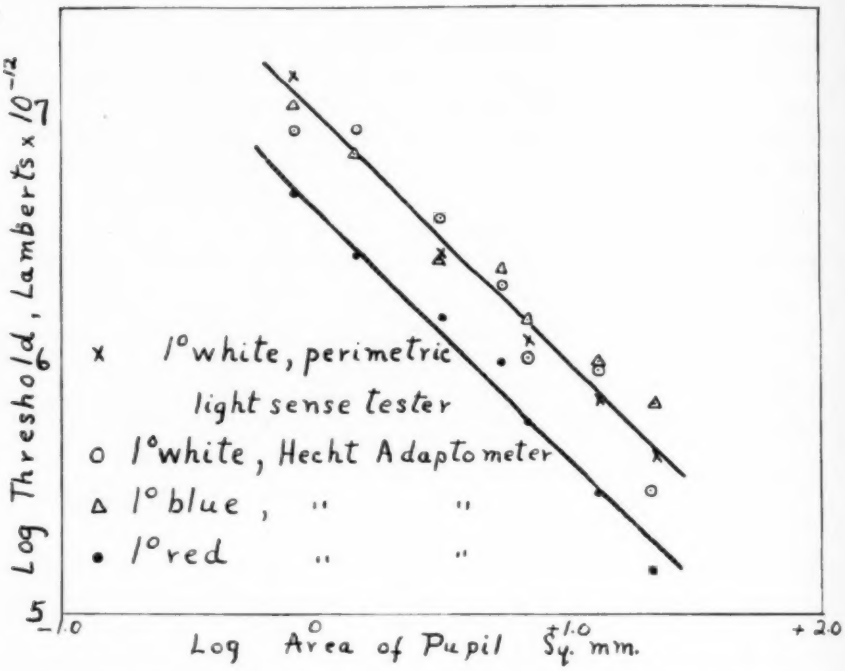

Fig. 4.—Foveal thresholds for 1 degree white, 1 degree blue and 1 degree red test objects.

One may conclude from these experiments that so far as the threshold measurements in the dark-adapted eye are concerned, whether the determinations are made at the fovea or in other parts of the retina, and whether made with white, blue or red light, the Stiles-Crawford phenomenon plays no significant role for pupillary diameters varying from 1 to 5 mm. It may validly be assumed, therefore, that retinal illumination is directly proportional to the area of the entrance pupil.

In clinical studies in which such threshold determinations are made in a group of patients, without standardization of size of pupil, it is therefore possible to eliminate this variable factor by measuring the diameter

of the entrance pupil and applying a suitable correction factor to the results. Figure 5 shows a calibration curve which may be used to correct threshold determinations to the values they would have if determined with a pupil 5 mm. in diameter. The correction factor to be applied to the experimentally determined values of log T for any given diameter of pupil may be read from this curve. If, for example, the thresholds were determined with a pupil 3 mm. in diameter, 0.45 must be subtracted from log T; if determined with a pupil of 7 mm., 0.29 must be added.

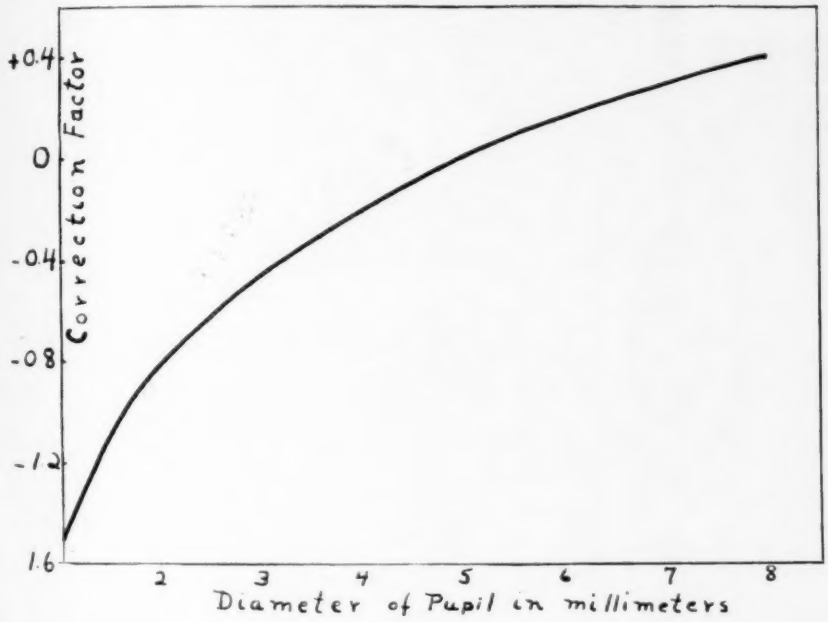

Fig. 5.—Correction factors to be applied to values of log T to give equivalent thresholds for a pupil 5 mm. in diameter.

An examination of figure 5 shows that the correction factors for different diameters of pupil greater than 5 mm. are almost negligible in relation to the normal daily variation in threshold determinations. Decrease in size of pupil below 5 mm., however, produces more marked changes in the threshold, so that in such cases the correction is of significant magnitude. In clinical studies, therefore, correction for size of pupil is of especial importance in testing subjects with abnormally small pupils and is of relatively little importance if the pupils are 5 mm. or more in diameter.

In a previous paper in this series,[11] preliminary data were reported showing measurements of the threshold throughout the retina from center

to periphery for normal persons and for those with pathologic ocular conditions. In these studies of regional differences in light sense, no corrections were made for size of pupil. The increases in threshold in the case of the subjects with various pathologic ocular conditions were either localized in certain parts of the retina or were of considerable magnitude, so that in either case they could not be attributed to reduction in effective intensity of the stimulus because of a small pupil.

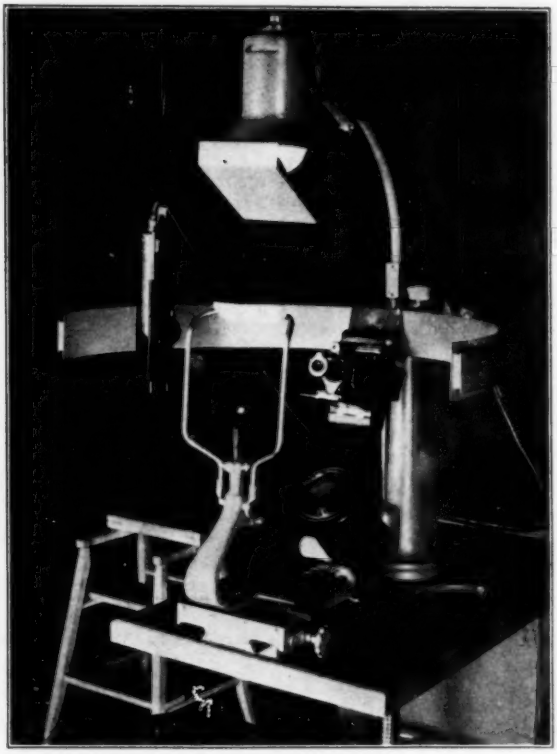

Fig. 6.—Camera and photoflash equipment in position for photographing pupil.

In investigating the range of variation in the thresholds of normal persons and in studying early defects in light sense of persons with conditions such as glaucoma and tabetic atrophy of the optic nerve in which differences in size of pupil may have a significant effect on the results, however, some means of measuring the pupil is desirable. Photography of the pupil has been found a satisfactory method except in the occasional instances in which ectropion uveae may introduce a source of error in the measurements. The diameter of the pupil when the eye is in darkness may be determined photographically by the use of a photoflash bulb,

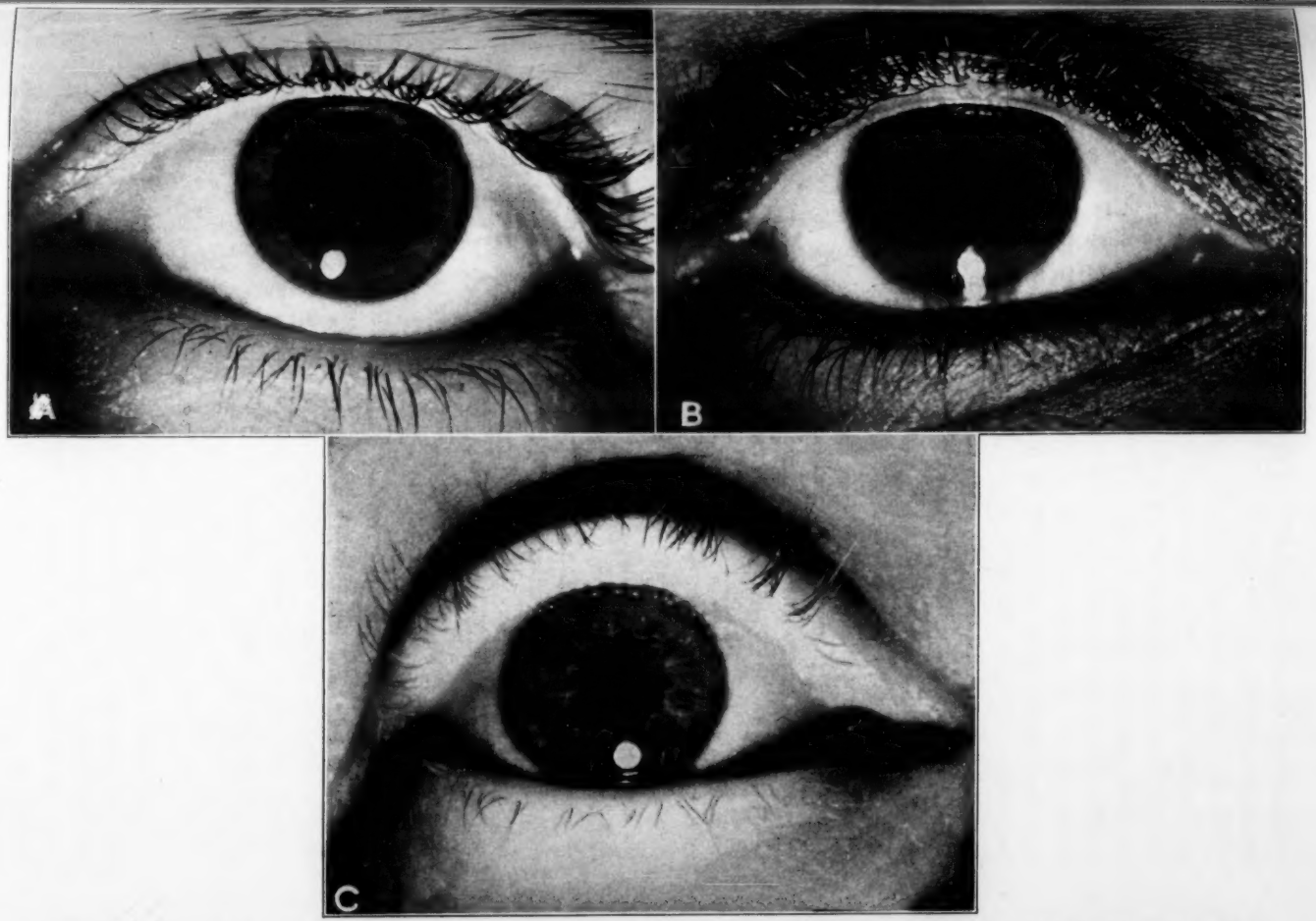

Fig. 7.—Photographs of pupils taken in the dark with photoflash bulb. *A*, pupil of a normal subject with a blue iris. *B*, pupil of a normal subject with a dark brown iris (Negro). *C*, Argyll Robertson pupil.

the duration of whose flash is less than the latent period of the pupillary reaction to light.

The camera used to photograph the pupil was modified from an inexpensive bellows type kodak, adapted to take plates instead of roll films. The camera is suspended from the perimeter arc at a fixed distance and in a fixed relation to the subject's eye when he places his head in the headrest and fixates the luminous red target. The distances from eye to camera lens and from lens to photographic plate are such that the magnification is unity when the eye is at exactly 33 cm. from the perimeter arc. The diameter of the photographic image of the pupil is measured on a comparator for greater accuracy than can be had by the use of an ordinary millimeter scale. An increase or decrease of 1 cm. in the distance of the eye from the perimeter arc produces approximately 6 per cent change in the photographed diameter of the pupil. This corresponds to a change of 0.05 in the logarithm of the computed area of the pupil and an error of the same amount therefore in the corrected value of the logarithm of the threshold.

In order to obtain satisfactory photographs of dark irides of Negroes as well as of white subjects, red sensitive photographic plates are used, and the illumination from the photoflash bulb is filtered through red gelatin placed in front of the reflector. The gelatin also serves to protect the eye from damage should the photoflash lamp bulb break when the foil is ignited.

Figure 6 shows the camera and photoflash equipment in place for taking a photograph of the pupil. The location of the photoflash bulb well below the visual axis produces a reflex in the lower part of the iris where it does not interfere with the measurement of the horizontal diameter of the pupil. This diameter is selected for measurement because the position of the camera at a slight angle below the visual axis produces a small error in the photographed image in the vertical dimension. Figure 7 shows photographs of several eyes. *A* is for a normal subject with a blue iris, *B* for a normal subject with a dark brown iris (Negro) and *C* for a patient with Argyll Robertson pupils. All three were photographed in complete darkness by the aid of the photoflash lamp.

SUMMARY

Measurements of the light minimum or threshold of the dark-adapted eye are influenced by the size of the subject's pupil. In order to correct the results of such tests on different persons for differences in size of pupil, it is necessary to know whether the effective retinal stimulation is directly proportional to area of pupil or whether, as certain experiments by Stiles and Crawford and others suggest, there may be a decrease in apparent pupillary efficiency with increase in area.

Experimental determinations of the threshold for a series of different sizes of pupil show that, within the accuracy of the measurements, the product, threshold times area of pupil, is a constant. It is therefore possible to reduce all threshold measurements made with different sizes of pupil to a comparable basis if the diameter of the entrance pupil is known.

A camera and auxiliary apparatus for photographing the pupil in the dark are described.

STUDIES OF THE VISUAL FIELDS IN CONNECTION WITH TRYPARSAMIDE THERAPY

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LAWRENCE, KAN.
AND
HERSCHEL S. SMITH, M.D.
OSAWATOMIE, KAN.

In most institutions where syphilitic patients are treated with tryparsamide, the value of periodic ocular examinations is recognized. Many workers in this field control medication with tryparsamide largely by periodic examinations of the visual fields. The following study is intended to show the state of the visual fields before, during and after tryparsamide therapy in both syphilitic and nonsyphilitic patients.

Since Lorenz and his co-workers [1] introduced tryparsamide in the treatment of neurosyphilis, the medical literature has contained a large number of reports concerning the effect of the drug on the visual mechanism. So contradictory have been these reports that one is at a loss to arrive at any definite conclusion as to the action of the drug on the eye. Woods and Moore,[2] in their complete report of the visual disturbances produced by tryparsamide, recognized the toxic nature of the drug. Lillie,[3] however, stressed the importance of the syphilitic process rather than the tryparsamide as the etiologic factor in the production of ocular symptoms. He has made observations that indicate greater prevalence of ocular symptoms in those who do not receive tryparsamide than in those who do receive this type of medication.

After reviewing the literature (Cady and Alvis,[4] O'Leary,[5] Menzies,[6] Ziskind,[7] Leinfelder [8] and Lees [9]), one must conclude that at times

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5. O'Leary, P. A.: Present-Day Status of the Treatment of Neurosyphilis, J. A. M. A. **109**:1163 (Oct. 9) 1937.

(Footnotes continued on next page)

tryparsamide does produce injurious effects on the eyes and that the administration of the drug should be controlled to a large extent by periodic ocular examinations. It is difficult and at times impossible to determine the part played by the syphilitic process and the damage caused by the tryparsamide in patients receiving this type of antisyphilitic therapy. That tryparsamide is associated with toxic ocular symptoms in nonsyphilitic patients has been shown by Pearce.[10] In her series of 77 cases of trypanosomiasis in which tryparsamide was administered, visual impairment developed in 9, in 3 of which the damage was permanent while in the other 6 complete recovery occurred.

The exact action of the drug has never been adequately worked out. The penetration of the central nervous system and the tonic effect, combined with a mild spirocheticidal action, all go to make the drug efficient in the treatment of syphilis of the central nervous system. One of the unique characteristics of tryparsamide is the tonic effect. After the first few injections there is usually observed a marked improvement in the mental condition, an increase in appetite and a gain in weight and strength.

In order that patients may be given the benefit of tryparsamide therapy without jeopardizing the visual mechanism, the administration of the drug has been controlled to a greater or lesser extent by some type of ocular examination. Woods and Moore [2] advocated the following procedures: Before tryparsamide therapy is started the eyes are carefully examined. Any organic defects, the visual acuity with refractive errors and the visual fields are accurately recorded. The patient is advised to report any visual disturbances, and if such occur the eyes are immediately reexamined. If no organic changes are found during this examination, the medication is continued. If any organic changes are found, the administration of tryparsamide is stopped. When the drug is not tolerated they found a concentric contraction of the form fields, affecting particularly the nasal, upper and lower fields, the temporal field being involved last or not at all.

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6. Menzies, E. C.: A Review of the Progress and Results in Forty-One Cases of Paresis and Tabo-Paresis Treated with Tryparsamide, Canad. M. A. J. **20**:242 (March) 1929.

7. Ziskind, E.: The Use of Drugs in Treatment of General Paresis, California & West. Med. **43**:21, 1935.

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9. Lees, R.: Results of Treatment of Tabes Dorsalis, Edinburgh M. J. **44**: 103 (June) 1937.

10. Pearce, L.: Studies on the Treatment of Human Trypanosomiasis with Tryparsamide, J. Exper. Med. **34**:1 (Dec.) 1921.

CLINICAL PROCEDURE

The patients used in the following study were selected from those admitted to the Osawatomie State Hospital. Three nonsyphilitic patients who were refractory to other types of treatment were used; the rest of the group were those whose condition was diagnosed as syphilitic meningoencephalitis and who were receiving tryparsamide and a bismuth preparation as antisyphilitic treatment.

Visual fields were taken one to four times preceding the first injection of tryparsamide, and an average of these readings was taken as the initial position of the field.

Tryparsamide was given to the syphilitic and nonsyphilitic persons in the same manner. The first dose was 1.5 Gm. intravenously; subsequent doses were 3 Gm. given at weekly intervals. So far as possible an examination of the visual fields was made preceding every injection of tryparsamide. The 16 patients

TABLE 1.—*Recordings from Perimeter Charts Showing the Method of Recording the Size of the Visual Field*

Date of Injection	Injection	0°	330°	300°	270°	240°	210°	180°	150°	120°	90°	60°	30°	Average	Average Change	Average Change of Both Eyes
Before treatment		84	78	72	54	48	44	55	53	46	38	47	62	57		
4/17/39.....	1	72	84	68	54	40	40	56	52	50	38	58	62	56	−1	−2
4/24/39.....	2	88	84	72	65	50	48	52	50	64	44	57	74	62	+5	+1
5/ 1/39.....	3	82	73	72	60	58	48	56	56	54	37	50	62	59	+2	−1
5/ 8/39.....	4	85	86	77	60	46	43	50	52	48	40	50	58	58	+1	+1
5/15/39.....	5	82	80	70	44	50	52	48	47	47	40	48	55	55	−2	−2
5/22/39.....	6	88	78	70	42	48	54	58	52	48	38	50	57	58	+1	−2
5/29/39.....	7	86	85	58	42	50	52	57	47	42	38	43	62	55	−2	−2
6/ 5/39.....	8	84	88	72	50	50	44	50	54	50	50	54	56	59	+2	+2
6/12/39.....	9	78	76	76	44	50	48	50	44	46	38	44	55	54	−3	−3
Administration of tryparsamide stopped																
7/17/39.....		78	80	70	48	50	46	54	44	42	36	48	62	55	−2	−4
8/ 1/39.....		78	80	72	56	52	48	54	50	46	36	48	57	56	−1	−2

The patient, A. C., at no time during the nine injections of tryparsamide showed any appreciable change in the visual fields. The data are recorded on the right eye.

considered in this study include only those who were cooperative enough to give accurate visual fields at least every week. A 3 mm. round white target at a distance of 33 cm. was used in all determinations. Recordings were made at intervals of 30 degrees.

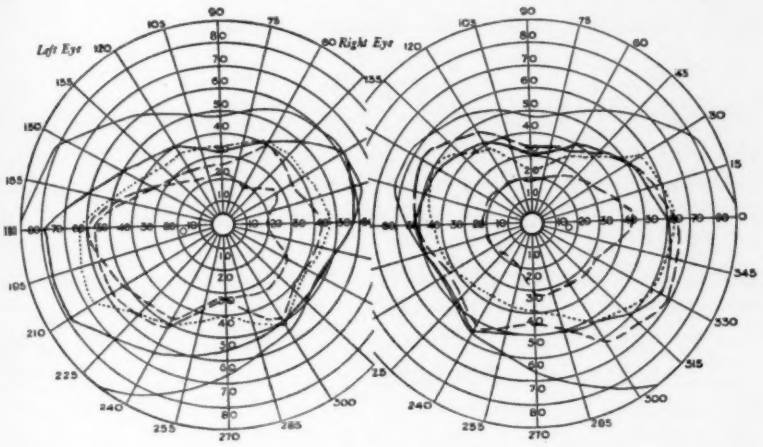
In computing the size of the field, each recording on the perimeter chart was tabulated, and an average of these findings was taken as a figure representative of the visual field as a whole. This averge figure was used in determining variations in the size of the visual field from week to week. Table 1 indicates the method by which these data were recorded and computed. It will be seen, therefore, that the changes in the visual fields, as tabulated here, are actual numerical quantities and not just impressions derived from observations of the perimeter charts (table 1).

RESULTS

As might be expected, the changes in the visual field from week to week varied for different persons. However, after studying table 2 it will be seen that in most cases there was a final decrease in the size

of the visual field, although in some there was no change, while in others there was a consistent increase in the size of the field (table 2).

A final decrease in the size of the visual fields was found for 11 of the 16 persons studied. The amount of decrease varied widely. The accompanying chart shows the weekly position of the fields of a patient



The position of the visual field before, during and after tryparsamide therapy in a case in which the drug was not well tolerated. The unbroken line represents the initial field; the outer broken line, the field taken one week after the first injection; the inner broken line, the field taken one week after the third injection, and, the dotted line, the field taken three weeks after the third and last injection.

TABLE 2.—*Weekly Change in the Visual Field Showing the Average Weekly Deviation in Degrees from the Visual Field Taken Before the First Injection of Tryparsamide*

Case No.	1	2*	3	4	5*	6	7	8	9	10	11	12	13*	14	15	16
Average initial field	52°	57°	53°	53°	64°	54°	66°	63°	47°	54°	61°	60°	56°	53°	46°	40°
Injection 1	−6	0	+7	0	−6	+4	+2	−1	+9	−15	−5	−2	−1	+3	+3	+4
2	−7	−7	+3	−5	−1	+3	+5	0	—	−11	−8	+1	+2	−2	+2	+4
3	−22	−8	+3	−6	−7	+5	−2	+2	+10	−12	—	−1	+1	+7	+12	+7
4	...	−8	−6	−9	−7	+1	−6	−1	+11	...	—	+1	−2	+4	+3	+12
5	...	−14	−18	−4	−8	−2	−4	−6	−5	...	—	−2	0	+3	+2	—
6	...	...	−23	−9	−8	+1	−5	−2	−11	...	−6	−2	−1	−3	+7	+11
7	...	...	...	...	...	−6	−5	−1	...	...	—	−2	−1	...	+6	—
8	...	...	...	...	...	−6	−5	−5	...	...	−4	+2	...	...	+7	+17
9	...	...	...	...	...	−3	−8	−8	...	...	...	...	...	...	+9	+8
10	...	...	...	...	...	—										
11	...	...	...	...	...	−7										

* Nonsyphilitic.

whose tolerance for the drug was low. A marked drop of this kind was found for 2 patients; 9 others showed a less pronounced but consistent contraction.

The fields remained essentially the same for 3 of the 16 patients. From table 1 it will be seen that the average deviation of 1 patient did

not exceed 4 degrees at any time. For another patient the recordings varied not more than 2 degrees while the tryparsamide was given.

About one half of the patients showed increases in the size of the fields. For 5 patients, this period of stimulation was followed by a continued, progressive depression, as shown by the data for F. K. in table 3. Two patients, however, showed an expansion of the field which remained throughout the course of treatment.

SUMMARY

Tryparsamide, not unlike many other therapeutic agents, has a tonic and a toxic action. The tonic action is manifest in the visual fields by an expansion, which is usually transient. The expansion frequently is associated with improvement in the patient's physical and mental condition. The toxic action is shown by a constriction of the visual field, which may occur during the first injections or may occur following the initial expansion associated with the tonic effect.

Tryparsamide, as a therapeutic agent, should not be discredited, but rather the promiscuous use of the drug should be strongly condemned. Persons who give this type of medication should be thoroughly familiar with the type of reaction that may be associated with its administration. Some type of control of the treatment, based on periodic ocular examination, should be instituted. Since studies of the visual fields show early toxic manifestations of the drug, this method seems to be a reliable method of control.

TABLE 3.—*Data Showing Early Expansion of the Field Followed by Constriction**

Date of Injection	Injection	0°	330°	300°	270°	240°	210°	180°	150°	120°	90°	60°	30°	Average	Change	Average Change of Both Eyes
Before treatment		58	62	73	54	52	44	53	48	44	37	44	55	52		
5/15/39	1	78	78	66	54	60	50	53	58	54	52	47	76	61	+9	+7
5/22/39	2	77	78	75	57	46	46	52	53	48	43	51	70	58	+6	+3
5/29/39	3	78	80	66	44	39	42	52	57	54	46	61	68	57	+3	+3
6/ 5/39	4	63	75	75	50	25	22	38	36	28	39	46	41	45	−7	−6
6/12/39	5	72	66	27	12	17	32	36	35	30	33	45	48	38	−14	−18
6/19/39	6	58	38	30	26	15	20	30	18	20	22	26	55	30	−11	−23
Administration of tryparsamide stopped																
7/ 3/39		47	30	22	17	12	14	27	23	18	21	20	33	24	−28	−26
7/17/39		52	26	30	20	17	26	30	18	30	17	24	48	28	−24	−24

* These observations were made on the right eye of F. K.

CONCLUSIONS

Tryparsamide therapy was associated with a constriction of the visual fields of 11 of the 16 patients studied.

Three patients showed no appreciable change in the fields.

Five patients showed an early expansion of the fields, which was followed by a constriction.

LOCAL ACTION OF OILS CONTAINING VITAMIN A

EXPERIMENTAL CONTRIBUTION

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Since Löhr [1] (1932) introduced the local application of cod liver oil in the treatment of infected wounds and osteomyelitis, it has been largely used and praised in surgical practice. The results of experimental works on this subject were not so uniformly good as those of clinical observations.

Drigalski [2] produced wounds of equal size in the skin of guinea pigs. Those treated with an ointment containing cod liver oil (unguentolan) healed more quickly than those treated with an ointment containing devitaminized cod liver oil. Devitaminized cod liver oil, however, may contain aldehydes and acids of irritating or poisonous action. Lauber and Rocholl,[3] on the other hand, attributed the healing property of the locally applied cod liver oil ointment chiefly to the base. They found that an ointment containing concentrated vitamin A, contrary to that of lower concentration, has an inhibitory action on the healing of wounds.

In Löhr's experiments the untreated wound showed a similar and nearly as rapid improvement as the wound of the same animal treated with cod liver oil. Löhr stated that local application to one wound helps in the healing of the untreated wound. Is this not suggestive of a systemic action? There is evidence that vitamins may be absorbed from wounds, as Saito [4] produced healing of rickets in rabbits with vitamin D in this way. Seiring [5] obtanied on the average equally good results with fatty acid solutions as with cod liver oil in treating wounds. He assumed that the action of fatty acids is the main factor in the treatment with cod liver oil. This idea is expressed in Löhr's conception as well: "With other investigators we share the view that the action of cod liver oil is

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1. Löhr, W.: Wundheilung, Leipzig, Johann Ambrosius Barth, 1937.
2. Drigalski, W.: Ueber lokale Vitaminwirkung bei Lebertranverbänden, Ztschr. f. Vitaminforsch. **3**:260, 1934.
3. Lauber and Rocholl, cited by Löhr.[1]
4. Saito, R., cited by Löhr.[1]
5. Seiring, H.: Fettsäurewirkung bei Lebertranverbänden, München. med. Wchnschr. **83**:1632, 1936.

due to a synergism of different components of cod liver oil, of which vitamin A and the unsaturated fatty acids seem to be the most important."

Clausen [6] in a recent résumé of "The Pharmacology and Therapeutics of Vitamin A" wrote: "The experimental work done throws doubt on any specific action of the vitamins contained in the preparations applied locally."

Notwithstanding the contradictory experimental data, the local application of vitamin A has been introduced into ophthalmologic, dermatologic and rhinologic practice and has been used in the treatment of cancer. Apart from the curative aspect, the scientific aspect of this form of therapy is of great importance.

The use of vitamin A in ophthalmologic practice for its epithelizing action, especially when corneal epithelium is involved, is a closely related idea. In regard to the clinical aspect of this form of therapy, it is known that the typical symptom of vitamin A deficiency, keratomalacia, is quickly relieved by the ingestion of foods containing vitamin A or by the internal administration of cod liver oil. This is an example of specific treatment. Such treatment has been proposed, however, for other ocular diseases which are not known to be connected with vitamin A deficiency.

Yudkin [7] found that the period of recuperation in cases of toxic amblyopia was shorter when vitamin A was given. Stocker [8] reported recovery in a couple of days in cases of superficial punctate keratitis. Food rich in carotene was less effective than cod liver oil. He assumed that in these cases there existed a disturbance in the production of vitamin A and of carotene from the food of the patient, probably due to a disturbance in hepatic function. Kentgens [9] measured the amount of vitamin A in the blood of patients suffering from corneal herpes, punctate keratitis, marginal ulcer, catarrhal ulcer, rodent ulcer and epithelial dystrophy. On the average, a subnormal concentration of vitamin A was found in a group of patients with corneal herpes and punctate keratitis. Administration of cod liver oil was found to be of great value in the treatment of these diseases. As it was given both locally and internally, one cannot know which form of treatment was

6. Clausen, S. W.: The Pharmacology and Therapeutics of Vitamin A, J. A. M. A. **111**:144 (July 9) 1938.

7. Yudkin, A. M.: Ocular Disturbances Produced in Experimental Animals by Dietary Changes: Clinical Implications, J. A. M. A. **101**:921 (Sept. 16) 1933.

8. Stocker, F.: Keratitis superficialis und Vitamin A, Schweiz. med. Wchnschr. **66**:335, 1936.

9. Kentgens, S. K.: Ueber Vitamin-A-Therapie bei Hornhauterkrankungen, Ophthalmologica **96**:3, 1938.

more effective. Pick [10] applied it in cases of scrofulous and herpetic keratitis and in a case of corneal degeneration complicated with rosacea keratitis with remarkably good result.

The local application of vitamin A was introduced into ophthalmic practice by Rachevskiy [11] (1934) on the basis that inflammatory tissue lacks certain vitamins. Carotene proved to relieve pain and to act as an anti-inflammatory agent. The period of healing was shortened in cases of non-pneumococcic ulcer, parenchymatous keratitis, pannus, neuroparalytic keratitis and chronic blepharoconjunctivitis. Kaptsiovskaya [12] used it in 71 cases of phlyctenular keratoconjunctivitis, dendritic keratitis, peripheral corneal infiltration and other ocular conditions. Stevenson [13] applied cod liver oil in 150 cases of corneal disease. It had "an undoubted and rather surprising efficacy as a healing agent." It seems to promote growth of the natural tissues and to inhibit growth of scar tissues. Heinsius [14] used a vitamin A ointment (2 per cent vogan), which corresponds to a good cod liver oil as concerns its content of vitamin A. Fresh corneal wounds, burns, recurring erosion, neuroparalytic and bullous keratitis, scrofulous keratoconjunctivitis and chronic blepharitis responded well to this treatment, epithelization being accelerated. Meshcherskiy [15] affirmed the experience of the aforementioned Russian authors. Possenti [16] treated 100 patients with an ointment containing cod liver oil. The disease presented by these patients included lymphatic and asthenic ulcers, trachoma, trachomatous xerophthalmos and blepharitis. Rinaldi [17] used a mixture of vitamins A and D, getting good results in cases of corneal ulcer, trachoma, scrofulous

10. Pick: Zur Behandlung degenerativer Hornhauterkrankungen, Ztschr. f. Augenh. **92**:230, 1937.

11. Rachevskiy, F. A.: Provitamin A as Anti-Inflammatory Factor in Diseases of Eye, Sovet. vestnik oftal. **4**:470, 1934; abstracted, Zentralbl. f. d. ges. Ophth. **32**:381, 1935.

12. Kaptsiovskaya, R. S.: Clinical Characteristics of Carotene Used in Treatment of External Diseases of the Eye, Sovet. vestnik oftal. **5**:242, 1934; abstracted, Zentralbl. f. d. ges. Ophth. **33**:191, 1935.

13. Stevenson, E.: Cod Liver Oil as Local Treatment for External Affections of the Eyes, Brit. J. Ophth. **20**:416, 1936.

14. Heinsius, E.: Ueber die lokale Verwendung von Vitamin-A-haltigen Salben in der Augenheilkunde, München. med. Wchnschr. **84**:936, 1937.

15. Meshcherskiy, N. N.: Carotene in Therapy of Herpetic Keratitis, Vestnik oftal. **10**:419, 1937; abstracted, Zentralbl. f. d. ges. Ophth. **39**:565, 1937.

16. Possenti, G.: L'alio di fegato di merluzza per applicazione locali in oculistica, Rassegna ital. d'ottal. **5**:96, 1936.

17. Rinaldi: Le vitamine A and D nel trattamento locale di lesioni corneali, Ann. di ottal. e clin. ocul. **64**:505, 1936.

ophthalmia and parenchymatous keratitis. Alvaro [18] used it for burns, electric ophthalmia, corneal infiltration, phlyctenular conjunctivitis and blepharitis. Intolerance of patients with corneal herpes for oils containing vitamin A is mentioned. Federici [19] proposed rather ointments containing cod liver oil, 10 to 50 per cent, instead of pure vitamins A and D. De Grósz [19a] has been using a vitamin A preparation, called vulnovitan (1 cc. of liquid petrolatum containing 1,000 international units of vitamin A). Local application of vitamin A "possesses a large field in ocular therapeutics; it represents an outstanding therapeutic agent especially for injuries and trophic conditions of the cornea."

Experiments concerning the local use of cod liver oil in the treatment of ophthalmic conditions affirm the clinical findings.

Rinaldi [17] scratched off the corneas of 11 rabbits almost to the point of perforation. The subsequent purulent infection improved sooner in the eyes treated with vitamins A and D, and the resulting scars were more transparent. Possenti,[16] experimenting on rabbits' eyes inoculated with various organisms, attributed a bactericidal power to cod liver oil ointment.

Heinsius [20] removed completely the epithelium from both eyes of rabbits and controlled the size of the defects with fluorescein. One eye of each rabbit was treated with cod liver oil or with unguentolan or vogan oil, all containing 750 international units of vitamin A per gram. The other eye was treated with liquid petrolatum. One drop was given three times daily. Epithelization occurred more quickly in the eyes treated with oils containing vitamin A. When the eyes in which the cornea became infected or in which epithelization was much delayed due to external factors were excluded, I found that for the remaining 12 rabbits of Heinsius' series 1 and 2 it required on the average of three and a half days for complete epithelization of vitamin A–treated corneas treated with vitamin A and five and one-third days for epithelization of the control corneas. Later Heinsius, referring to another series, wrote: "This small difference, namely, one or two days, according to my view is attributed to other factors acting on regeneration, which has nothing to do with the therapeutic action." And if one considers

18. Alvaro, M. E.: Observaciones sobre la acción de la vitamina A en oftalmologia, Arq. clin. oftal. e otol. **5**:111, 1938; abstracted, Zentralbl. f. d. ges. Ophth. **43**:199, 1938.

19. Federici, E.: Le vitamine A e D nei processi di riparazione della cornea (studio sperimentale), Boll. d'ocul. **16**:357, 1937.

19a. de Grósz, S.: Local Use of Vitamin A Preparations in Ophthalmic Practice, Arch. Ophth. **22**:727 (Nov.) 1939.

20. Heinsius, E.: Experimentelle Untersuchungen über den Einfluss des Vitamin A auf die Regeneration des Hornhautepithels, Arch. f. Ophth. **136**:103, 1936.

series 3, in which the action of pure vitamin A oil (vogan) is compared with that of cod liver oil, one finds that 8 rabbits, excluding 1 with an infected eye, 2 animals with delayed healing and 2 in which just a slight abrasion was performed, showed an average period of epithelization of four and four-fifths days, nearly the same time as for the eyes of the rabbits in series 1 and 2 treated with liquid petrolatum. In all these experiments the whole cornea was abraded. This means probably the inevitable injury of unequal portions of the limbus, which is most important in considering regeneration of the cornea. Briefly, the careful experiments of Heinsius are not sufficiently convincing as to the epithelizing action of locally applied vitamin A.

It seems important at this time to add some new experimental data on this subject.

EXPERIMENTAL SERIES 1

The first series of experiments were carried out on rats with keratomalacia. Visible changes due to the administration of vitamins are naturally most conspicuous in case of avitaminosis. Cod liver oil produces no changes of the cornea when given internally to a normal person, but it has a curative action on keratomalacia. The question is, does cod liver oil heal keratomalacia when applied locally? Keratomalacia was produced in rats in order to study this question.

The rats used for this group of experiments were reared by mothers getting a diet consisting of one-fourth whole dried milk and three-fourths whole ground wheat for twenty-five to twenty-eight days. The rats weighed 35 to 44 Gm. at this time. They were then placed in individual cages and received a diet of Sherman and Burtis consisting of 18 per cent vitamin A–free casein, 67 per cent corn starch, 10 per cent yeast, 6 per cent salt mixture of Osborne and Mendel and 1 per cent sodium chloride. Water was given as desired. Four control rats on this diet (nos. 9, 10, 15 and 22) died in forty-nine, forty-eight, thirty-nine and thirty-eight days, respectively. The first ocular symptoms, such as puffy lids and viscid sanguineous-tinged secretion, were observed on the thirty-eighth, thirty-first, thirty-fourth and thirty-third days of the depletion period, respectively. Another series of rats (nos. 301 to 311) were given a vitamin A–deficient diet composed of 18 per cent vitamin–A free casein, 53 per cent corn starch, 15 per cent hydrogenated oil, 10 per cent irradiated yeast, and 4 per cent salt mixture. On this diet the symptoms were delayed; the first ocular symptoms appeared on the fiftieth to the fifty-sixth day of the depletion period, and the control animals died on the sixtieth to the sixty-ninth day.

The description of Yudkin [7] concerning the appearance of the ocular symptoms was confirmed. In all rats keratomalacia was preceded by the formation of a thick keratinized layer in the upper fornix; when this layer was thrown off the hyperemic but shiny, smooth conjunctiva became visible.

Group A.—Eight rats received twice daily a small drop of cod liver oil in the right eye when the first ocular symptoms, puffy, sticky lids and keratinization in the upper fornix, appeared (nos. 2, 14 and 18) or when actual keratomalacia developed (nos. 4, 12, 304 and 308); otherwise the same deficient diet was given. The weight of the small drop of cod liver oil was 2.2 mg., its vitamin A content

(1,000 international units per gram) being 2.2 international units and the daily dose being 4.4 international units, corresponding to 2.65 micrograms of carotene. Daily doses of about 3 to 5 micrograms of the international standard when administered to young rats suitably prepared on a vitamin A–deficient diet have been found adequate to restore growth and cure xerophthalmia. Unit doses of either alpha or beta carotene daily are sufficient to enable steady but subnormal growth, but 0.5 microgram is inadequate according to Chinn.[21]

The first 3 rats (nos. 2, 14 and 18) showed no more pathologic symptoms after ten days of treatment and gained 10 Gm. or more during this period. Improvement was noticed on the sixth, sixth and seventh day, respectively. Two of the 4 rats (nos. 4 b and 308) that were treated after keratomalacia developed showed improvement on the tenth day. The important fact is that the improvement occurred in both eyes of these 5 rats simultaneously, though only the right eye had been treated. Two of the rats (nos. 12 and 304) with keratomalacia died on the third and seventh day of the treatment, respectively. The keratomalacia of both rats was of the marked diffuse type. The cod liver oil seemed to have been administered too late to avoid the complete breakdown of the organism. Even the keratomalacia made further progress until the death of the rats. Reference is made here to the findings—degenerative lesion of corneal nerves—of Mallenby [22] in the late stage of keratomalacia. He found evidence which suggests that xerophthalmia in vitamin A deficiency may be secondary to a loss of neurotrophic control. There is probably a stage when the histologic change is irreversible.

The eighth rat (no. 305) deserves special mention. On the sixty-first day of the depletion period the right cornea was normal and the left cornea showed a gray, nonpurulent ring and a dry surface. Cod liver oil was applied to the right eye. The infiltration of the left cornea progressed for three days, then showed improvement and cleared up.

Two other rats (nos. 4 and 7) were given the same amount of cod liver oil orally instead of locally. Rat 7, which did not have any corneal involvement, became normal on the eighth day. In rat 4, which had a dry conjunctiva and sanguineous secretion, a gray cornea developed during the first days of treatment but showed improvement on the eighth day. Changes occurred simultaneously in both eyes.

In group A, a minimal dose of vitamin A in the form of cod liver oil was dropped into one eye of the 8 rats showing beginning xerophthalmia or keratomalacia. The daily amount of vitamin A corresponded to 2.65 micrograms of carotene. The rats were kept on the vitamin A-deficient diet. Two of the rats showing advanced keratomalacia died in the first days of treatment. In the surviving 6 rats the ocular symptoms or the keratomalacia disappeared always simultaneously in both eyes. The animals had gained weight in the meantime.

Group B.—Three rats (nos. 2b, 21 and 22) were administered a small drop of halibut liver oil in the right eye twice daily. The weight of a small drop was 1.7 mg., its vitamin A content (50,000 international units per gram) being 85 international units, equaling 51 micrograms of carotene and corresponding to 102

21. Chinn, H.: The Mechanism of Production of Xerophthalmia in the Albino Rat and Its Prevention by Alpha and Beta Carotene, Thesis, Northwestern University Graduate School, 1935.

22. Mallenby, E.: Xerophthalmia, Trigeminal Degeneration and Vitamin A Deficiency, J. Path. & Bact. **38**:391, 1934.

micrograms daily. Rat 21 had dry, opaque corneas and was cured completely in three days. Rat 2b had several corneal infiltrations of the right eye; the left eye was normal. On the fourth day the infiltration was but one third of its original size, and the animal had gained 30 Gm. Rat no. 22 was treated when it was in a bad general condition, suffering from weakness and grave keratomalacia; it received but 2 drops and died on the next day.

In this group 2 of the animals had a stormy recovery, the condition in both eyes always being parallel. The third animal died on the second day of treatment.

Group C.—Four rats (nos. 14, 18, 25 and 26) were treated twice daily with a small drop of coconut oil in which beta carotene was dissolved, or rather suspended, as the fine crystals did not dissolve completely. One small drop, 1.4 mg., contained 1.4 micrograms beta carotene, the daily dose being 2.8 micrograms.

Rat 14 had an opaque right cornea and purulent infiltration of the other cornea. On the sixth day of treatment there was improvement of both eyes, and on the thirteenth day healing was noticed. Rat 26 did not show any corneal opacity on the ninth day. The finest opacity of the cornea of rat 25 stayed the same for fifteen days, when the animal died. Rat 18 died on the fifth day of administration of carotene when the opacity of the cornea was improving.

In group C one eye was treated with beta carotene with daily doses of 2.8 micrograms. In 2 of 4 rats the keratomalacia cleared up in thirteen and nine days, respectively; 2 other rats died on the fifteenth and the fifth day of treatment, respectively, 1 showing no change of the keratomalacia and the other slight improvement. The administration of beta carotene in one eye was followed by corneal change in both eyes of all rats.

Group D.—For group C the carotene was suspended in coconut oil. The question arises: What is the local action of the oil on the cornea in vitamin A–deficient rats? Coconut oil contains practically no vitamin A. Two rats received coconut oil in the right eye, twice daily. The treatment for rat 301 was started when there was sanguineous-tinged secretion but a shiny cornea. On the fourth day the right cornea was normal and the left cornea slightly opaque. On the sixth day the right cornea showed a minimal opacity, and the left cornea was moderately opaque. On the eleventh day the right cornea was totally gray and the left cornea suppurated. The animal died on the sixteenth day. On the eleventh day of administration of coconut oil to rat 304 the right eye was normal and the left cornea partially gray. The animal died on the fifteenth day. In both instances the coconut oil exerted some protective effect on the right, treated cornea.

What is the protective value of liquid petrolatum against keratomalacia? Liquid petrolatum was applied twice daily to the right eyes of 5 rats (nos. 1, 6, 13, 17 and 31) on a vitamin A–deficient diet. All showed the same changes with slight quantitative differences. For instance, treatment with liquid petrolatum was started for typical rat 17 on the twenty-second day of the depletion period, thus about eight to ten days before the keratomalacia was expected to develop. On the seventh day of treatment the animal showed a desquamating upper fornix; on the fourteenth day both corneas were shiny; on the twenty-fourth day the right cornea was normal and the left slightly opaque; on the twenty-eighth day the right cornea was normal and the left opaque and dry; on the thirty-second day the right cornea was slightly opaque and the left very opaque, the animal dying on the same day. The liquid petrolatum had a protective action on the right treated eyes of all 5 rats. The duration of life was not changed by this treatment compared with that of the negative controls.

Experiments carried out on vitamin A–deficient rats by administering coconut oil or liquid petrolatum in one eye show that oils devoid of vitamin A have a

definite protective action on the cornea. This action is purely local, does not apply to the contralateral cornea and consists in a delay of the keratomalacia. The animal may even die before keratomalacia develops in the eye protected with oil.

Group E.—How long does this protective action of vitamin A given conjunctivally last? Three rats (nos. 2b, 14b and 18b) with keratomalacia were treated with cod liver oil for twenty-five, thirty-one and forty-five days twice daily. After that period the administration of cod liver oil was discontinued. Keratomalacia developed again on the ninth, nineteenth and thirteenth day, respectively. In rat 2b keratomalacia developed first in only the right eye, the eye which had been treated previously with cod liver oil. Both corneas of rat 14b became opaque, but the left one suffered purulent infection. Both corneas of rat 18b showed the same degree of cloudiness.

Two rats (nos. 2 and 21) were treated for keratomalacia with halibut liver oil for ten and twelve days, and after this period the administration of halibut liver oil was discontinued. During a further period of sixty days the animals were kept on the deficient diet, but no keratomalacia was observed. This is contrary to what occurred in the rats treated with cod liver oil. The difference between the reactions is due to the great difference in the amount of vitamin A in the two oils. The rats given cod liver oil received daily 4.4 international units of vitamin A for twenty-five, thirty-one and forty-five days, that is, 110, 136 and 198 international units, respectively. Those given halibut liver oil received daily 170 international units of vitamin A for ten and twelve days, respectively, an amount of 1,700 and 3,040 international units. This must have been sufficient for several months.

Oils containing vitamin A when applied to the conjunctiva are able to prevent and cure keratomalacia. Most effective is halibut liver oil; suspension of beta carotene in coconut oil has proved to be less effective than cod liver oil, though the amount of vitamin A was about the same in both, 2.8 and 2.65 micrograms of carotene, which is a little more than the minimal amount for maintenance (1 to 2 micrograms). This prophylactic and therapeutic action is simultaneous and equal in the two eyes when only one eye receives the treatment. On the basis of the improvement of the systemic condition and the gain of weight, it is clear that these oils or vitamin A, respectively, exerted a systemic action. The microdrop, about 1.5 mg., was purposely used to prevent the overflow of the drop which would possibly be wiped off by the paws of the animal and eaten. By this means it was supposed that the greatest amount of the oil could act locally. Even so, the oil could have entered the nasal cavity through the lacrimal canaliculi and have been swallowed. No local effect whatsoever of the cod liver oil could be observed on the cornea, and the changes in the untreated eye were the same. If cod liver oil was administered in the eye for two weeks or longer, loss of the hairs on the lids was noticed. Oils, of course, have a soothing, protective action, of which great use is made when liquid petrolatum or peanut oil is administered in many cases of corneal involvement. The rats in group D also showed that keratomalacia may be delayed by even the local application of liquid petrolatum or coconut oil, while the contralateral eye is severely involved.

The locally applied oils containing vitamin A have a systemic effect. Whether vitamin A is resorbed by the surface of the eye or enters the circulation through the lacrimal duct and digestive apparatus has not been investigated. The drop was purposely small to avoid the overflow of the oil. It is possible that oils containing vitamin A have a local action similar to that of oils containing no vitamin A, but that the systemic action is so potent that it covers the local action. On the other hand, the local action of oils lacking vitamin, the purely physical protecting, soothing action, is so effective that it may delay or even prevent the development of keratomalacia.

EXPERIMENTAL SERIES 2

Cod liver oil has been recommended for the treatment of a series of corneal diseases regardless of the need of vitamin A of the patient. This treatment is based on the supposition that cod liver oil has a favorable local action; such action could be ascribed to the biologic action of vitamin A and vitamin D, to the chemical action of fatty acids and to the physical action of the oil.

It is known that vitamin D bears no relation to the cornea; its deficiency does not produce any corneal symptoms. The epithelizing action of vitamin A is claimed to be of use in corneal diseases. Experiments of Rinaldi and Heinsius confirmed the clinical findings and theoretic supposition. But in the experiments of Rinaldi infection developed, the corneal stroma being severely injured. It is hardly possible to produce the same degree of pathologic changes in both eyes of the same animal as Rinaldi did, namely, by scraping off a large portion of corneal stroma, with the development of a spontaneous purulent keratitis. This condition is not suitable for testing the action of vitamin A, especially as the animals were not kept on vitamin A–deficient diet. Objections concerning the precise experiments of Heinsius have already been stated.

In a series of experiments (data in the accompanying table) I believe I produced fairly equal epithelial defects on both corneas of rabbits kept on a diet containing carrots, although to be sure it was not a vitamin A–deficient diet, because I wished to examine only the local action of vitamin A. Trephines of 5 (rabbits 1 to 4) and 6.5 mm. (rabbits 5 to 8) were used with a slight pressure to mark the area in the center of the cornea, which was carefully deprived of its epithelium, the size of the defect being controlled by fluorescein. The right eye received a drop of cod liver oil and the left eye a drop of liquid petrolatum twice daily. In a third group (rabbits 9 to 12) nearly the whole corneal epithelium was scratched off with fine sandpaper. The instrument employed consisted of a round wooden shaft 10 mm. in diameter, the end of which had been gouged out to form a concavity of 8 mm. radius; into this depression was cemented a concave disk of 000 waterproof sandpaper. This procedure as controlled by fluorescein left about 1 mm. of the most peripheral epithelium; thus injury of the limbus was avoided, which would have caused unequal conditions in eyes of the same animal.

Adding the time necessary for epithelization of the right eyes treated with cod liver oil and that of the left eyes treated with liquid petrolatum, the total is 772 and 778 hours, respectively, in these 12 experiments. This is no essential difference in such experiments. I fully agree with Heinsius that there are many factors, especially mechanical ones, which may cause a slight difference in the healing time.

Equal defects of corneal epithelium in rabbits need the same time for recovery when treated locally with cod liver oil or with liquid petrolatum.

Time Required for Epithelization of Cornea When Treated with Cod Liver Oil and Liquid Petrolatum

Rabbit	Diameter of Epithelial Defect	Eye	Epithelization in Hours				
			40	48	66	72	90
1	5	Right	..	..	+*	..	..
		Left	..	+	..	..	..
2	5	Right	+	..	..	..	..
		Left	+	..	..	..	..
3	5	Right	..	+	..	..	..
		Left	..	+	..	..	..
4	5	Right	..	+	..	..	..
		Left	..	..	+	..	..
5	6½	Right	..	+	..	..	..
		Left	..	..	+	..	..
6	6½	Right	..	+	..	..	..
		Left	..	+	..	..	..
7	6½	Right	..	..	+	..	..
		Left	..	..	..	+	..
8	6½	Right	..	..	+	..	..
		Left	..	..	+	..	..
9	10	Right	..	..	..	+	..
		Left	..	..	..	+	..
10	10	Right	..	..	..	..	+
		Left	..	..	..	+	..
11	10	Right	..	..	..	..	+
		Left	..	..	..	..	+
12	10	Right	..	..	..	..	+
		Left	..	..	..	..	+

* Time when complete epithelization of the denuded corneal area was noticed.

SUMMARY AND CONCLUSION

Locally applied cod liver oil introduced by Löhr for treatment of wounds has found favorable reception by many surgeons. Experiments as to its action, however, are contradictory. Its local application for the treatment of ophthalmic conditions has been praised by several authors, even in diseases which have not been considered as being connected with vitamin A deficiency.

Experiments (Heinsius and Rinaldi) affirming the therapeutic action of locally applied vitamin A on the cornea are not sufficiently convincing. Two series of experiments were carried out to clarify this problem.

In a first group of experiments keratomalacia was produced in rats; they were kept on the same deficient diet, and the action of oils containing vitamin A and of beta carotene when dropped in the eye was

examined. Daily doses of vitamin A or 4.4 international units as cod liver oil, 170 international units as halibut liver oil and 2.8 micrograms of beta carotene in coconut oil were administered. The daily dose was given in 2 microdrops, the weight of a drop 1.4 to 1.7 mg., so as to prevent the overflow of the oil from the conjunctiva. Cod liver oil and halibut liver oil have prevented the outbreak of keratomalacia or cured it, unless given in a very late stage of the disease. The regression of keratomalacia was observed simultaneously in both eyes, though only one eye was treated. In 1 rat keratomalacia developed in one eye only; this cleared up when the other nonaffected eye was treated. Action of oil containing beta carotene proved to be less effective, though the quantity dropped in the eye daily was about the minimal maintenance dose for rats.

Liquid petrolatum or coconut oil when dropped in one eye delayed the outbreak of keratomalacia only in the eye treated. Animals on this treatment died after the same length of depletion period as other non-treated animals.

When rats with keratomalacia were treated with cod liver oil and the treatment discontinued after two weeks, the disease reappeared in both eyes in a couple of days when the vitamin A–deficient diet was continued. In 1 rat it even recurred first in the eye previously treated with cod liver oil.

The conclusion to be drawn from the first series of experiments is that oils containing vitamin have a definite systemic, not a local, action when applied to the eye. It is not known, however, whether it is resorbed by the surface of the eye or whether it reaches the stomach through the nasal duct.

In a second series of experiments the question investigated was whether cod liver oil or vitamin A has an action on corneal epithelization in animals not suffering from vitamin A deficiency. The experiments of Heinsius were repeated with modified technic. Equal portions of epithelium were scraped off the corneas of rabbits. A trephine and a special instrument were used to get exactly equal defects in both eyes and not injure the limbus. There was no difference in the time necessary for epithelization when the right eyes were treated with cod liver oil and the left eyes with liquid petrolatum. These experiments do not confirm the idea that vitamin A acts locally to promote epithelization.

Oils have, as has long been known, a favorable, protective action on superficial corneal lesions. Oils containing vitamin A have this action, too, but there is no evidence in these experiments of a local action of vitamin A. When dropped in the eye, vitamin A proved to exert a systemic action.

A MORE NEARLY ABSOLUTE METHOD OF TESTING AND RATING VISION

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Perhaps the most widely used test of human powers is that of acuity of vision. In proportion as it is widely used there is need to provide a good and as far as possible a foolproof equipment. As the situation now is, the testing of vision is one of the most loosely conducted tests. Not only has there been no substantial change in the principles, test materials and procedure of making the test since the days of Snellen, but even the principles laid down by him are not complied with in a great part of the testing that is now being done. So far as restriction or supervision is concerned, almost any type of test chart may be used under any type or intensity of illumination. The variable difficulty of the task to which the eye may be subjected under these conditions of testing is a sufficient guarantee that consistency of result will not be obtained in testing the same person at different times and in different places and that the test will not serve the important purpose for which it is intended.

With respect to the type of test chart, it may be noted that capital letter charts have been sold and used without difference or distinction, some having the letters constructed to meet the 1-5 minute requirement of the Snellen rating scale so far as this is possible with capital letters as test objects and others in which no attempt has been made to meet the 1 minute requirement for the size of the critical details, even when manufactured and sold by the same firm. Moreover, in the best of these charts the letters in the same line do not approximate equally well even the 5 minute requirement of the scale for the gross size of the test object. The test objects, too, differ widely as to form. Therefore, in all the capital letter charts the test objects in the same line in all these respects, gross size, size of detail and form, set a greatly different discriminative task for the eye. Obviously this presents an impossible situation with respect to the formation of a rating scale. Inaccuracies in the dimensions of the letters used are also of frequent occurrence.

From the Research Laboratory of Physiological Optics.

In former papers [1] we have discussed the subject of testing and rating vision broadly. It is our purpose in this paper to discuss it only with reference to the comparative merits of the capital letter charts and a new chart, the double-broken circle chart, which has recently been made available to the public.

A new method of rating vision made possible by this chart is also described, namely, a rating in terms of power to discriminate detail in the four principal meridians of the eye—horizontal, vertical and the two oblique. This rating is directly in terms of acuity of vision, the function to be measured, not in terms of the power to recognize and name objects; also it shows whether or not an inequality is present in the different meridians (an astigmatism) and roughly indicates the location.

CAPITAL LETTER CHARTS

Capital letter charts are defective in four important regards: the test object, the type of judgment, the construction of the charts and the rating scale.

Test Object.—Acuity of vision depends on two functions: the power to form correct images and the power to discriminate detail in these images. Two factors contribute to the power to form correct images: sharpness of focusing, the lack of which causes blurring, and uniformity of focusing in the different meridians, the lack of which causes distortion of form. A good test object, then, must have form to serve as a check on distortion, and it must have a sufficient number of critical details to test correctness of focusing in a sufficient number of meridians of the refractive system. The critical details, moreover, must be uniform in size.

With respect to these requirements, it may be said in general of the capital letters as test objects that in order to prevent memorizing a considerable number of capital letters have to be used and that it is impossible to find a sufficient number which will constitute a uniform check on distortion and correctness of focusing in the different meridians of the refracting system and set a uniformly difficult task for the discrimination of detail in the different meridians of the retina. The different letters set an unequal task for the resolving power of the eye, that is, an unequal check on the blurring of the image and on the power of the retina to discriminate detail in the image. The angular values of the

1. Ferree, C. E., and Rand, G.: The Testing of Visual Acuity: I. Factors Influencing the Sensitivity of the Test for the Detection of Errors of Refraction, Am. J. Ophth. **17**:29-36 (Jan.) 1934; II. The Comparative Merits of Test Objects and a New Type of Broken Circle as Test Object, ibid. **17**:610-618 (July) 1934; III. Types of Test Field and a New Projection Apparatus, ibid. **17**: 1147-1150 (Dec.) 1934.

details to be discriminated in letters which, according to the Snellen plan of construction, are inscribed in squares of the same size varies in some charts that are in common use from 1 to 3 minutes or more. Further, there is added a wide range of complication as to form. In proportion as there is this wide variation as to form, there is wide variation in the check which is set on distortion. Nor do letters so constructed have the same gross or overall size. The letters O, C and G, for example, when inscribed in a square the angular value of the sides of which is 5 minutes at the eye, do not have the same overall size as the letters E, F, P, B, etc. Therefore, even with respect to this aspect of the letter, they do not set the same discriminative task for the eye. When capital letters are used as test objects, then, the Snellen plan of inscribing all the letters that occur in the same line of the test chart in squares of the same size does not give these letters equality or equivalence in any respect—gross size, size of detail or liability to distortion. With double-broken circles as test objects, however, this is not the case. All test objects so constructed have the same overall size, the same size of detail and the same liability to distortion. Moreover, the dimensions of the test object in any direction, i. e., along the various diameters, actually subtend an angle of 5 minutes at the eye, while with the letter E, for example, only the sides of the letter subtend an angle of 5 minutes at the eye. The diagonal dimension subtends more than 7 minutes at the eye.

It should be well recognized by this time that the letters used in the Snellen series present a number of well marked degrees of difficulty of discrimination even when correctly constructed to meet as nearly as possible the 1-5 minute requirement of the Snellen scale, yet all the letters in the same line on the chart are given the same value in the unmodified Snellen plan of rating vision. Also, it may be noted that in the various series of capital letters planned to subtend a 5 minute angle at the eye which have been used from time to time in the construction of charts and in those which are still being used the construction of the letters in all cases is by no means the same nor is the 1-5 minute requirement met in all.

Just what is meant by the 1-5 minute requirement of the Snellen scale does not seem to be uniformly understood. The 5 minute requirement refers to the overall size of the letter and the 1 minute requirement to the size of detail that has to be discriminated. Unfortunately in many charts in use today the requirement as to the overall size of the letter is all that is even attempted. In *A* of chart 1 is shown the letter E drawn to the 5 minute scale, and in *B*, the letter drawn as nearly as possible to the 1-5 minute scale. Even in case of the letter E, a favorable letter for the purpose, it is seen that not all the details which have to be dis-

criminated can be made to subtend a 1 minute visual angle. In *C* is shown the double-broken circle, the test object adopted for use in the chart to be described in this paper. In this chart it can be seen how easy it is accurately to construct the double-broken circle to meet the 1-5 minute requirement when the breaks or openings in the circle are the details to be discriminated; that is, how easy it is to make the overall size of the test object 5 minutes and the openings 1 minute.

An important point to be noted in connection with these test objects is the difference they give in the rating of vision. A test of this shows that with the object given in *B* vision is rated around 14 or 15 per cent higher than with the object given in *C* and with the object given in *A*, around 30 to 35 per cent higher. These values will be found to vary somewhat with the intensity of light and the subject tested. Wherever a judgment is based on recognition, for example, considerable individual variation may be expected. There can be little doubt which of the ratings as given by the three test objects is the most nearly correct, for the task set by the object given in *C* is the discrimination of an accurately

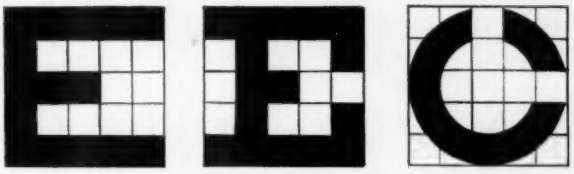

Chart 1.—*A*, the letter E drawn to the 5 minute scale. (In the construction to the 5 minute scale, custom seems to vary with respect to the length given to the middle bar of the E.) *B*, the letter E drawn as nearly as possible to the 1-5 minute scale. *C*, the double-broken circle drawn to the 1-5 minute scale.

constructed detail and the judgment is in terms of the power to recognize the detail, while the task set by the objects in *A* and *B* is a complicated one of the discrimination of details of various sizes, each contributing an indeterminate amount to the total result, and the judgment is in terms of recognition. By common agreement, vision and visual acuity would be defined, we believe, as the power to discriminate detail; yet with the use of test objects of the capital letter type by the conventional method of testing, they are measured in terms of the power to recognize objects.

As further illustrating the variability in the capital letters with respect to the size of the details that have to be discriminated, chart 2 has been prepared. In this chart letters have been chosen from the charts that are being printed by two leading optical companies. At the left of this chart the attempt is made to construct the letters to meet as nearly as possible the 5 minute requirement alone of the Snellen scale

(we have already shown that even Snellen's construction of the capital letters does not meet the 5 minute requirement of the scale which he adopted and further that only test objects circular in form could meet this requirement); and at the right of the chart the attempt is made to meet both the 1 minute and the 5 minute requirement. The large squares in which the letters are inscribed are intended to represent the *approximate* overall or 5 minute size, and the small squares, the 1 minute size of the details to be discriminated. In inspecting this chart, there-

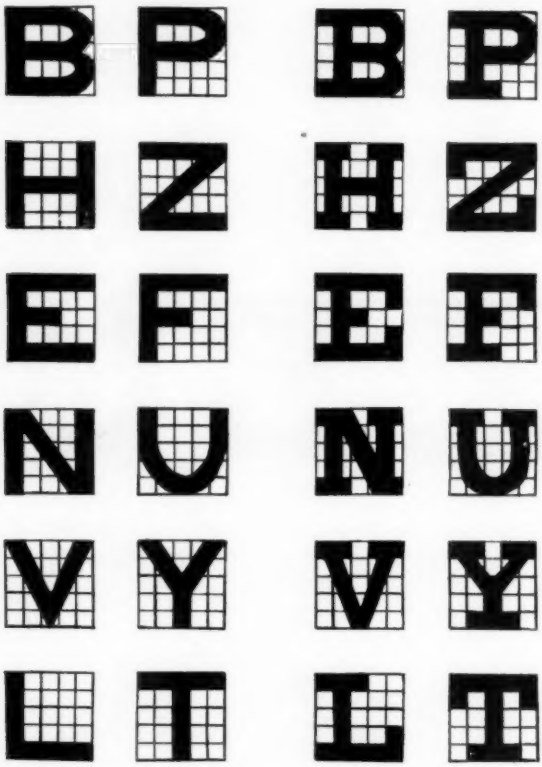

Chart 2.—Twelve of the capital letters commonly used in visual acuity charts, drawn in 1-5 minute scale blocks to show their differences as test objects. In the two columns on the right the letters are constructed as nearly as possible to meet both the 5 minute requirement of the Snellen scale as to overall size and the 1 minute requirement as to size of the critical details; in the two columns on the left no attempt is made to satisfy the 1 minute requirement. In both types of construction it is seen how far the letters come from satisfying either of these requirements. Some of the letters meet more nearly the 1 minute requirement than others and some more nearly the 5 minute requirement; and all the letters differ from each other in gross size, size of critical detail, complexity as to form, liability to distortion, ease of recognition and difficulty of discriminative task set to the eye. With such test objects a satisfactory rating scale is impossible.

fore, the small squares may be used to measure and compare the size of the details which have to be discriminated, and the large squares, the overall size.

As we have already stated, we have known both types of charts to be sold by the same optical company without any advisement, instruction or perhaps even knowledge that they cannot be expected to give the same result. When there is added to the variability in test charts the variability of intensity of illumination that is found in testing from time to time and from place to place, there is little wonder that such unsatis-

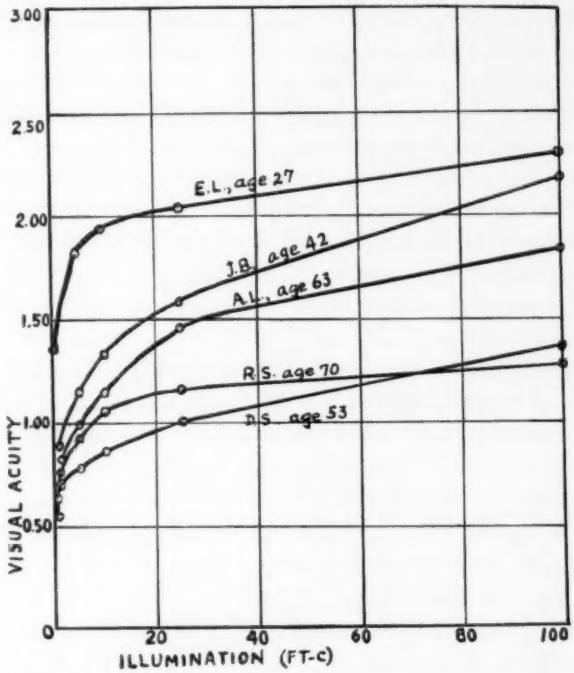

Chart 3.—Effect of increase of intensity of illumination on visual acuity at different ages.

factory results should occur in the testing and rating of vision. To make the situation worse, the effect of intensity of illumination on visual acuity varies widely with the age of the person tested. To this is added still further a variable technic on the part of the examiner, that is, variation in the way in which the charts are used. The effect of intensity of illumination on visual acuity at different ages is shown in chart 3.

The testing of visual acuity is essentially the testing of the space sense. The space sense is well recognized as being the most reliable and consistent of the sensory functions. On this account it has ever

been chosen as the preferred field by psychophysicists for demonstrating the psychic functions have a regularity which may be reduced to law. Also, its superiority, its certainty and its precision have been so well recognized by physicists that they have reduced wherever possible the reading of their instruments to dials, scales and similar devices. If the special testing of this aspect of the space function known as visual acuity is found to be unsatisfactory, it is clearly the fault of the procedure that is employed. If a proper test object is used under carefully standardized conditions, the test can be made one of the most, if not the most, satisfactory practical test of human functions.

The letters of the alphabet were devised to serve a useful purpose, but that purpose was not to function as scientific test objects. For this they are entirely too variable and irregular as to overall size, size of detail that has to be discriminated and liability to distortion. Tests based on their use might be regarded as specific performance tests, but only with regard to power to read the alphabet. But this is only a part of the work involved in space discrimination that the eye has to do. Further, no specific performance test can be regarded as a fundamental test of the power of the eye to discriminate detail. Also, in general, specific performance tests cannot be reduced to a satisfactorily graded scale.

Obviously the use of a multiplicity of test objects of unequal difficulty, such as the capital letters, presents insurmountable difficulties with respect to such important points as the type of judgment that can be used and the possibility of reducing to a uniformly graded scale. Fortunately the use of such test objects is not necessary.

As an alternative plan, a single test object can be used which will present only one difficulty of task, serve as an adequate check on distortion and have a sufficient number of details of uniform size which can be presented in a sufficient number of positions to test the power to discriminate detail in an adequate number of meridians. Such a test object is the one we have called the double-broken circle.[2] In this test object two details uniform in size are located in meridians 90 degrees apart to prevent meridional accommodation when a cycloplegic is not used. This test object can be printed in a sufficient number of positions of rotation to check the correctness of focusing and to set an equal task to the power of the retina to discriminate detail in the more important meridians. This we have done in constructing the double-broken circle test chart. In this connection it may be noted that when the double-broken circle is used as a test object only two positions are needed for each size of object to make the test in the four principal meridians of the eye—horizontal, vertical and the two oblique.

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2. Ferree, C. E., and Rand, G.: A New Visual Acuity and Astigmatism Test Chart, Am. J. Ophth. **20**:21-32 (Jan.) 1937.

Considering the variety of meridians in which the defect may occur, the circle perhaps more than any geometric form is subject to distortion by astigmatism. The double-broken circle is particularly subject to distortion. It may be elongated, flattened or doubled, and breaks may appear to occur where they are not. This extreme liability to distortion is an important factor in giving the double-broken circle its high sensitivity for the detection of small degrees of astigmatism when the correcting cylinder is rotated before the eye. Only a slight deviation of the axis from the correct location, for example, is needed to cause a detectable change in the appearance of the double-broken circle and of a chart made up of a collection of double-broken circles.

Type of Judgment.—As already noted, with capital letters as test objects the judgment required is in terms of recognition and necessarily has to be because of the type of object used. To be recognized, objects need not be seen clearly. The results obtained are thus not in terms of the function tested and sustain an indeterminate relation to that function. In the use of test objects of the type of capital letters it would not be easy to make the judgment in terms of one or more critical details of uniform and measured size. The judgment in terms of recognition is inherent in the type of test object used.

In previous papers we have discussed and demonstrated the effect of various factors in the determination of acuity. We have not, however, as yet shown the effect of type of judgment, and it is not our intention here to do that work in detail. That will be reserved for a later paper. We wish here merely to note the factor and to give some slight indication of the magnitude of its importance. With the test objects shown in chart 1, for example, this can be done in two ways. (*a*) The first method consists in comparing the result with the test object given in *C* with that given in *B*, as has been done in the preceding section. The test object shown in C, the double-broken circle, is accurately constructed to the 1-5 minute scale and that in B to that scale as nearly as is possible with the letter E. The difference in result, around 14 or 15 per cent, is due, therefore, almost if not entirely to difference in type of judgment. (*b*) The second method consists in comparing the result when the task set is the discrimination of the 1 minute opening of the letter E, as shown in *B* of chart 1, with that obtained when the task set is the recognition of the letter. In our test of this point the result obtained for power to recognize the object was again around 14 or 15 per cent higher than for power to discriminate the 1 minute opening. In case other letters of the alphabet having a 1 minute detail were used, this value would be expected to vary with the form and other structural features of the letter.

It may further be noted that the test of power to recognize belongs of necessity dominantly to the class of what are called specific per-

formance tests, not to the class of basic tests of capacity; that is, the result will vary with the object that has to be recognized. For example, as already noted, there is not equal power for the recognition of different capital letters even when constructed to the same scale. Further, this power will not be the same for other objects as for the capital letters. Obviously, the power to recognize varies both with the type of object and with the person under examination over and above the power to discriminate detail.

While it may be worth while to test the power of recognition in a rating of human capacities, the test has to be made for each object separately. The results obtained for no one alone can be taken as measuring a person's power to recognize. Because of the low transfer value of the results obtained, little general importance is usually ascribed to such tests, and they are used no more than can be helped in a program of testing. It can thus readily be seen that it is wrong to make a basic test of vision in terms of the power to recognize and not well to substitute power to recognize for a basic test of vision. From the standpoint, then, of both correctness of principle and reproducibility of result from person to person and from time to time with the same person, a type of test should be employed with which the judgment of power to discriminate detail not only can be conveniently used but is required.

The Construction of the Chart.—In addition to the selection of a satisfactory test object, the other important requirements in a test chart are accuracy in the construction of the test objects and the use of a sufficient number of sizes of test objects.

In relation to the first of these requirements, accuracy in the construction of the test objects, we have found not only that all the test objects used in commercial charts do not conform to the 1-5 minute requirement of the Snellen scale but that the greater number of them are not accurately constructed to any scale. Again we will confine our observations to charts of the capital letter type. We have measured the test objects on a number of different models of chart of this type with a micrometer comparator and have found astonishing inaccuracies both as to the size of the letter and as to the angular value subtended by the critical details. In many cases the error amounted to as much as 25 per cent. Further, errors were found both in the absolute size of the test objects and in the relation of sizes of objects in the different lines. This revealed a new and important fact in the explanation of the differences in the ratings of acuity obtained for the same person when tested in different places. This, we understand, is a common complaint of those who are required to test the ocular fitness of candidates for various branches of service in the United States Army and Navy and in other lines of testing service where there is a chance for an inter-

comparison of results. Other factors contributing to this variability of result are the number of letters selected for use in the construction of the chart (in the charts examined this varied from seven to twenty); the fitness of the letters selected for meeting the requirements of a measuring scale and their distribution in the different lines of the chart; the variability in different charts with respect to the 1-5 minute requirement of visual angle; differences in the reflection factor between object and background; differences in the glazing or sizing of the card and in the flatness of the ink; differences in the intensity and diffuseness of the illumination used and the angle at which the light falls on the test surface, and the way in which the test is conducted.

In making the chart to be described in the present paper great care was exercised both in the construction of the original template and in all photographic reproductions and reductions. It will be readily seen that the fact that we had only a single template to construct instead of 7 to 20, as is the case in the letter charts, was a great advantage both in the amount of work that was required and in the accuracy it was possible to obtain. Measurements were made to one thousandth of an inch by means of a micrometer comparator. These measurements were made of the original template, of the image on the plate of the camera before the film was exposed, of the developed impression on the film and of the printed test character. In making the measurement of the image on the plate of the reducing camera, a special device had to be made for mounting the micrometer comparator. We feel that we can guarantee a most unusual degree of accuracy in the master chart we have constructed. Further, we wish again to point out the advantages of the test object selected with respect to the ease and accuracy with which it can be used in constructing a chart. The latter feature has seemed much more important to us since we have checked the accuracy of charts of the capital letter type.

The second of the foregoing requirements, the use of a sufficient number of sizes of test object, has always presented a great deal of difficulty in the construction of charts. In the capital letter charts usually not more than eight or nine sizes are used, and these are so distributed as to test inadequately eyes of poor and better than medium vision. Normal variations of vision with age and intensity of illumination are also poorly provided for in the selection of sizes that is made. For example, under 10 foot candles of illumination young emmetropic eyes and young eyes well corrected for refractive error are much more apt to have an acuity of 1.5 to 2 than of 1 and a vision of 20/15 to 20/10 than of 20/20. There is certainly no less need for the finer measurements of acuity for the young than for the middle-aged eye and no less need for skill and refinement in the correction of refractive errors.

Indeed, extra care in refraction yields its best results in young eyes. Eyes with poor vision also need special care and attention, not so much because of the superior results that can be obtained as because of the great need for improvement and for the detection of small changes in case of treatment. It seems strange that a measuring scale which was established when so little was known about acuity, its measurement and the factors which affect it should have remained so long with so little change. Certainly enough is known about these matters now to justify a revision and an adequate standardization.

Further, in the capital letter charts great irregularity is introduced both in rating and in refractive practice by the great variability in the number of test objects employed for the different sizes. For example, in the different charts the number of test objects used may vary from eight or nine in the 20/20 line to one in the 20/200 line. There are two reasons for using as many test letters of the same size as possible, namely, to test the refractive discriminative powers in the different meridians and to prevent memorization. There is an undue and unnecessary liability in respect to the latter feature because the judgment is in terms of recognition. Also, because the judgment is in terms of recognition, there is need for a greater number of objects to test the resolving power in the different meridians.

With the use of the double-broken circle there is great improvement in these respects. Only two positions of the test object are needed, for example, to test the resolving power directly in the four principal meridians of the refracting system—horizontal, vertical and the two oblique—and, therefore, it is possible to use a greater number of sizes within the dimensions of the customary test chart; also, the danger of memorization is greatly reduced by making the judgment in terms of power to discriminate detail rather than to recognize and by turning the openings in the eight cardinal directions in haphazard order in the same line and from line to line. Not only, then, does the double-broken circle have superior merit in all the important aspects of a test object, but its employment in the construction of a chart permits the use of a greater number of sizes—a feature in itself, other things equal, of decisive importance.

The Rating Scale.—For the purpose of rating vision, the test object, or test objects, should be of such a type as will satisfy the requirements of a rating or measuring scale. These requirements are: accurate measurability of detail, serial arrangement according to size, adequate fineness of gradation or sufficiency in number of steps or divisions in the scale and accurate specification of each division or step in the scale and of the relation between the different steps in the scale. They are best met by a single test object having only one size of critical detail which

is easily measurable and can be accurately constructed according to scale. Again attention is called to the double-broken circle. It can be easily and accurately measured and constructed to scale, and the clear discrimination and correct location of its critical details in the various positions require correctness of focusing in all meridians.

If in a rating scale based on size of object or visual angle more than one type of test is used, all that are of the same size should present the same difficulty of discrimination to the eye or at least have the same order of discriminative difficulty. Also they should in relation to the plan of rating neither overestimate nor underestimate visual acuity. As has already been pointed out, the structural features of many of the letters of the alphabet are such that they could not be given equal rating in any scale, physically determined, and the greater number of them are given a false rating in the scale employed by Snellen. In other words, the test objects chosen by Snellen, namely, the capital letters, do not even satisfy the requirements of his own scale. It should be definitely understood here that we do not object to the Snellen scale as a plan of rating. What we do object to is that the capital letters cannot be constructed to meet the requirements of this scale. If, for example, the letter L were to appear in the same line with the double-broken circle and the letter B, it would by no means set the same task for the discriminative powers of the eye as those objects. In the double-broken circle the critical details, as should be the case in the plan of rating, subtend a solid angle of 1 minute at the eye. In the letter B only the shorter dimension of the details presented subtends an angle of 1 minute. In the letter L, as constructed in some of the charts which have been and still are in use, however, the opening between the constituent vertical and the horizontal members at its broadest point, which is an important if not the critical detail, subtends an angle of more than 5.5 minutes. Just what rating the letter L should have in comparison with the double-broken circle, the letter B and the various other letters which are used in the printing of test charts would be difficult to decide a priori, but it is not difficult to understand that the results obtained with this letter greatly overestimate acuity.

In 1916, it will be remembered, the Committee on Standardizing Test Cards for Visual Acuity, of which Dr. Edward Jackson was chairman, published a report in which is given the comparative visibility of the letters of the alphabet which can most nearly be constructed without distortion to meet the 1-5 minute requirement of the Snellen scale. Of the eighteen letters used, even when correctly constructed, the same visibility was never assigned to more than two of the group and the range of visibility in the group was in the relation of 1 to 0.71. The use of these letters as test objects and units of measurement would be

analogous to using footrules varying in length from 8½ to 12 inches as a standard of linear measurement. Under such circumstances no physical rating of the scale can be accepted as measuring visibility, and a proper subjective calibration would require the use of a large number of observers, would be extremely difficult to accomplish and would at best be somewhat uncertain. Obviously, if ratings are to be made and norms established, the task would be greatly facilitated by adopting a single test object of suitable form or type.

It has already been pointed out that such a test object would have to be circular in form accurately to subtend a 5 minute angle at the eye and that the double-broken circle satisfies the 1-5 minute requirement of the Snellen scale; that is, when constructed to scale, the gross or overall size is 5 minutes, and the size of the critical details, the two breaks in the circle, is 1 minute. Also, in general it satisfies completely all the requirements of a physical rating scale.

The capital letters, on the other hand, do not satisfactorily meet even the most fundamental requirements of a measuring scale. The construction of a measuring scale presupposes the selection of a unit or portion of the thing to be measured that is maintained equal in value or magnitude or is in correctly graded proportions throughout the scale. The capital letters present a multiplicity of units—one for each letter that is used; that is, the plan of the Snellen scale is that the gross size of the test object shall be 5 minutes at the distances specified for the different lines on the chart and the size of the critical details 1 minute. For the capital letters the gross sizes are not 5 minutes nor are the sizes of detail 1 minute, and the deviations from these sizes are different for the different letters. In such a situation comparison, evaluations and other methods of study are difficult and numerical ratings impossible. Can any one say that the task set by the first line of a chart which contains only the letter L sustains any known relation to that set by the second line, which contains the letters T and E, or to any other line of the chart? In different charts, too, the total number of different letters used per chart varies widely—seven, fourteen, eighteen, twenty, etc., distributed in various ways in the different lines. This situation is further complicated by the fact that the number of letters used in the different lines may vary from one to eight or nine. Thus, considering either the individual letters in the line or the line in toto as a division in the scale, the situation is hopeless for the purpose of numerical comparison or measurement.

The use of such a plan in the construction of a scale of physical magnitudes would receive scant consideration, and test letters as such are, it will be remembered, physical magnitudes and can be treated as physical magnitudes. Any attempt to treat the lines of letters on the

chart as divisions in a subjective scale would, as already indicated, require an enormous amount of calibration, an amount that thus far has been found to be prohibitive in any department of sensory work. Considering the test letters as physical magnitudes, it is obvious that much greater possibilities for rating and measurements are at one's command with the use of a single well selected object of the sizes that are wanted. In such a case, when all other factors that affect one's powers of discrimination are held constant, a good rating and measurement of vision can be made so far as a physical scale can be used to measure a sensory function. The alternative is the use of a scale subjectively calibrated which, we have already pointed out, is a practical impossibility. Also, by the use of a test means such as the double-broken circle chart the work of diagnosing and correcting refractive errors would be substantially improved.

It is by no means our wish here to take the attitude of radical reform, but it will do no harm to think of these things and to remember that ophthalmology, also the science of measurement, has made great advances since the time of Snellen. It would be comparatively simple, for example, to construct a scale the divisions of which would set tasks for the eye's powers of discrimination as nearly numerically comparable as is possible in the present state of knowledge of the relation of these powers to size of object. All that would be required for such a scale are the selection of a suitable type of test object properly graded and distributed as to size, a standard color and intensity of illumination, standard coefficients of reflection of object and background and a standard coefficient of gloss or finish for the cardboard or other background on which the test objects are presented, or the equivalent of these in case a projection system is used. For this purpose the double-broken circle with its openings turned in different directions is excellent as the test object. For a suitable intensity of illumination, it might be suggested that an attempt be made to approximate the standard of lighting practice. However, standards of practice in commerical lighting change greatly from time to time, and, moreover, it is difficult at any one time to determine just what the standard is. Again, the aim in commercial lighting is by the use of high intensities and other methods to give all eyes good vision, that is, to eliminate as far as possible individual differences. This is hardly suitable for a scale the purpose of which is to rate eyes fairly as to their powers of vision, in other words, to bring out all the individual differences that actually exist. For this purpose it would seem better to select a medium intensity, for example, 10 foot candles. For the sake of simplicity of specification and of equipment required, the intensity could, without sacrifice of fitness for the purpose, be made the same as is now commonly accepted for perimetry and the study of the visual field, namely, 7 foot candles.

We recognize that the force of many years of habit is strong and hard to overcome. In spite of analyses, experimental proofs and the findings of committees, many examiners will continue to use what they are accustomed to. However, with respect to the obligation involved, private practice and public service present different cases. In private practice the interest is perhaps most often dominantly in refractive correction, and the examiner works on his own responsibility. In public service the responsibility is broader, and the feelings and prejudices of the examiner should, of course, have no place. In any case it is clear that there should be available and be used where it is particularly important to have a correct rating of vision, a test chart and test method that will give accuracy, precision and reproducibility of result, for example, in the United States Army, the United States Navy, the military and commercial air service, all kinds of traffic service, schools, industries and similar places.

THE FERREE-RAND DOUBLE-BROKEN CIRCLE CHART

The double-broken circle chart in the form in which it is constructed for practical and professional use is shown in chart 4.[3] It will be discussed under the following headings: the test object, the test chart and method of using it, the report of the testee, the rating of vision and auxiliary advantages.

The Test Object.—The following facts may be noted: 1. The details to be discriminated are the breaks or openings in the circle. These openings all subtend 1 minute of arc at the eye at the distances specified on the chart. The entire test object subtends 5 minutes of arc at these distances. Thus the test object conforms to the 1-5 minute requirement of the Snellen rating scale.

2. In a single test object the two openings are separated from each other by 90 degrees, thus simultaneously testing the clearness of the images formed on the retina in meridians at right angles to each other. This is an important point, since it prevents the eye from making any accommodative adjustments to correct for inequalities in imaging power in the different meridians when a cycloplegic is not used.

3. In the test objects taken collectively, the paired openings are rotated into eight positions sustaining to each other such relations as to test the clearness of the image in the four principal meridians—horizontal, vertical and the two oblique (45 and 135 degrees)—and at eight positions on the retina. These paired positions are up and right, up-right and down-right, down and right, down-right and down-left,

3. The chart may be obtained from the Bausch and Lomb Optical Company, Rochester, N. Y.

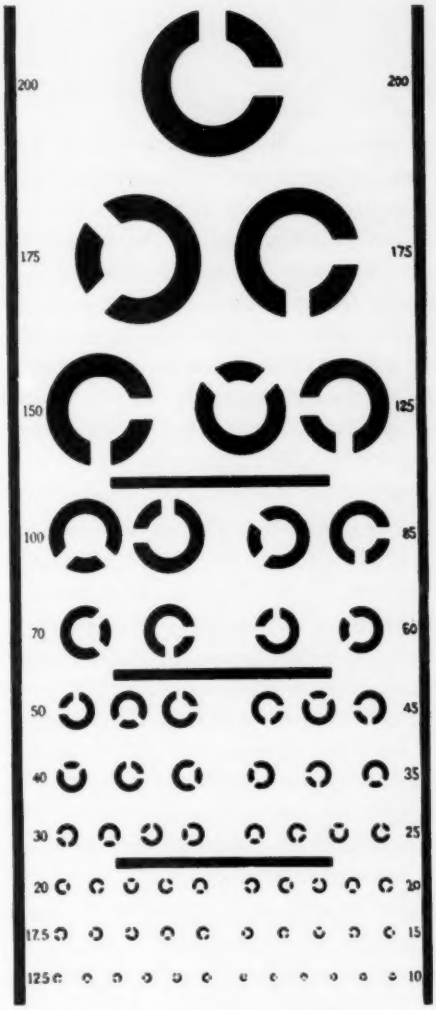

Chart 4.—The double-broken circle test chart. In each position of the test chart discriminative power is tested simultaneously in meridians at right angles, thus preventing any accommodative adjustment for astigmatism. Because fewer test objects of a size are required, it is possible to use a greater number of sizes. Nineteen sizes are provided with enough test objects of each size to test discriminative power in the four principal meridians (eight positions). Scale of sizes is filled out to take care of deficiencies usually found in test charts for testing poor and better than medium vision. The test chart is of great value in detecting astigmatism and indicating its meridian; it also adds sensitivity to use of the rotating cylinder and crossed cylinders. Other features are: The test directly measures power to discriminate detail, judgment not being in terms of recognition. The test objects completely satisfy the 5 minute requirement of the Snellen scale as to overall size and the 1 minute requirement as to the size of critical detail. Details to be discriminated (breaks in circle) are simple and easy to grade in size and to construct accurately. The same type of task is set by objects in different lines and an equal task by all objects in the same line, an accurate rating scale being readily possible. An objective check is had on the judgment. High sensitivity and close reproducibility of result can be obtained. The test objects are difficult to memorize and are also suitable for children and illiterates. The method of scoring is absolute in type, namely, in terms of number of meridians in which critical detail can be discriminated. The score shows whether astigmatism is present and indicates approximate location.

down and left, up-left and down-left, up and left, up-left and up-right. In this connection it may be noted that the opening at either the top or the bottom in the vertical meridian, at either the right or the left in the horizontal meridian and in either half of the two oblique meridians will test the clearness of the image formed in those meridians, respectively, and, therefore, that only four positions of the openings, or two test objects of any given size, are needed to make the test in the four meridians. Because of this we have been able to use on a chart of convenient dimensions more than double the customary number of sizes—one of the more important improvements that are needed in the equipment for testing visual acuity.

4. Since inequality in the power of the lens and cornea to form a correct image on the retina in different meridians is called astigmatism, the test objects provided constitute a test for astigmatism within the fine limits of delicacy of the just noticeable difference in the clearness of discrimination of detail as well as a test of vision. In this connection it may be of interest to note that a poor power of imaging in the vertical meridian blurs the image formed in the horizontal meridian. From this it can be seen that a break in the circle in the horizontal position, right or left for example, tests the clearness of the image formed in the horizontal meridian and the correctness of the image-forming power in the vertical meridian and that in correcting this defect the curvature of the cylinder is placed in the vertical meridian and its axis in the horizontal meridian.

5. That the type of test object employed is admirably adapted for use with a rating scale and that the judgment is solely in terms of the function to be measured, namely, the power to discriminate detail, should be readily obvious.

The Test Chart and Method of Using It.—Nineteen sizes of test object are provided.[4] Because of the narrowness of the chart, the customary size, 10 inches (25 cm.), in each of the first two lines only one size of test object could be used. In all the other lines two sizes are used with the exception of the 20 foot (6 meters) line, where again there is only one size and a correspondingly greater number of test objects of that size. Where two successive sizes occur in the same line, the customary sizes are in the first half of the line and the intermediate sizes in the second half.

It will be remembered that in the test object used, the paired openings can be rotated into eight positions sustaining to each other such relationships as to test the clearness of the image formed in the four

4. These sizes are for the following distances: 200, 175, 150, 125, 100, 85, 70, 60, 50, 45, 40, 35, 30, 25, 20, 17½, 15, 12½ and 10 feet (60, 52.5, 45, 37.5, 30, 25.5, 21, 18, 15, 13.5, 12, 10.5, 9, 7.5, 6, 5.25, 4.5, 3.75 and 3 meters).

principal meridians—horizontal, vertical and the two oblique—and at eight positions on the retina. In constructing the chart the purpose was in general to use for each size of test object at least one of the four possible positions of rotation in which the horizontal and vertical meridians are tested and one of the four possible positions in which the two oblique meridians are tested; if more than two test objects of a size are used, the remaining positions of rotation are included in random order. In these cases for the sake of uniformity of procedure in making the test only two of the positions of rotation need be selected, for example, one in which the openings are up and right and the other in which they are up-left and down-left. The choice of these paired positions may be made to suit the purpose of the examiner. The other positions may be used as alternates to give variety and to prevent memorization in successive tests.

In order to save time, the recommended procedure is to use only the sizes in the first half of the line (the customary sizes) until the limit of vision is reached or nearly so and then the intermediate sizes for a more exact determination. The limit of vision should not be regarded as reached so long as any one of the openings used is reported in its correct position.

The chart should be placed at a distance of 20 feet and illuminated with well diffused light of medium intensity. The intensity we have recommended for use in ophthalmology is 7 foot candles. The use of higher intensities, as stated earlier, renders the test insensitive for detecting errors in refraction and for picking up differences between persons and differences in the same person from time to time. This is due to the fact that increase of intensity of light increases both the focusing action of the pupil and the power of the retina to discriminate detail in a blurred image, and thus tends to iron out differences between persons and the differences that occur in the same person from time to time. Glare should be eliminated from the source of the illumination and as far as possible from the test surface. During a single test and from time to time the light should not vary in either intensity or color, since both of these factors, particularly intensity, exert an important influence on the results obtained with an acuity test.

The use of intensity of light in testing the eye is just the reverse of what it is in lighting. In lighting, intensity is used to compensate for errors in the formation of the image and in its discrimination; in correcting errors of refraction it is used in a way that will most clearly reveal defects in the formation of the image and in testing vision in a way that will most clearly reveal defects both in the formation of the image and in its discrimination. In earlier days there was great confusion on these points. In testing the eye as well as in lighting, the

tendency was to use high intensity of light and to give a correspondingly clearer vision of the test object. Happily today it is known that this is not the correct procedure.

If the chart is to be used for making the visual acuity test alone it is preferable that the examiner stand at the chart and point to the particular test object he wants to have discriminated. He should be able to select at will any test object he chooses or any sequence of test objects that best serves his purpose. If, however, the chart is to be used for making a refractive correction, the procedure customarily employed by the refractionist can, of course, be used.

The Report of the Testee.—Two items of information are sought: How many openings are there and what is their location in the circle or in what direction do they point? Subjects, we find, differ so much in their natural way of designating direction that we usually let the testee choose his own method by showing him a test object of a size well within his power of discrimination and getting his reaction. Our own method is to use the terms up, down, right and left for the four cardinal positions and up-right, up-left, down-right and down-left for the intermediate ones. Some prefer to say north, south, east, west, northeast, northwest, southeast and southwest; others choose the numerals on the dial of a clock and say 12 o'clock, 3 o'clock, etc.; still others, usually children and illiterates, point or move the arm or hand in the eight directions. By allowing the testee to use his own method, we have never experienced any difficulty in using the chart with children, illiterates, those who do not know right from left and the various other samples of humanity who may stray into one's laboratory or office.

The Rating of Vision.—As already stated, the limit of vision should not be regarded as reached so long as the testee is able *correctly* to report the location of an opening in any meridian; the failure to locate it in one, two or three meridians should be designated as —1, —2 or —3, as the case may be. In recording data it will be found helpful to note the meridians in which these failures occur, e. g., 20/20 —1 (meridian 90 degrees). Also, the information so recorded would be of great service in arriving at the final determination of the strength and placement of the correcting cylinder. In this connection it should be remembered that the curvature of the cylinder should be placed in the meridian of maximum clearness of discrimination and its axis in the meridian of maximum blurring.

A perfect score for any size or line of test objects requires that the openings be *correctly* located in all four principal meridians. In making the test for these four meridians, two test objects of the same size may be used, one of which, as stated earlier, tests the horizontal and vertical and the other the two oblique meridians, or as many more as may be

desired in those lines which have more than two of the same size, provided that the scoring is done in terms of meridians, not in terms of number of test objects as is the case in the letter charts. In this connection it again should be borne in mind that while there are eight positions of the opening, two positions test each meridian and that therefore there are only four meridians to be taken into account.

For interpreting the results obtained, it will be found helpful to the examiner to familiarize himself in advance with the appearances that are produced by the various refractive defects. Minus and plus spheres held before either an emmetropic or a properly corrected eye will serve to demonstrate the appearance of the test object in hyperopia and myopia, respectively, and cylinders rotated before the eye, the appearance for astigmatism in different meridians. To produce the appearances that are found in compound astigmatisms, combinations of spheres and cylinders are required.

In the double-broken circle chart it is readily seen (*a*) that the rating is not in terms of power to *recognize* letters or other objects of widely differing complexity and size of critical detail and (*b*) that by scoring in terms of power to discriminate detail in the four principal meridians of the eye—horizontal, vertical and the two oblique—the rating is made independent of the various kinds of chart that may be used (capital letter charts and other types) with their various types and complexity of test object, their inequality in the same line as to both these respects and as to overall size of test object and size of detail and their unequal number of test objects in the different lines all differing in all these respects in the same line. The rating may thus well be said to be absolute in terms of power to discriminate detail in the more important meridians of the eye—the function which the visual acuity test purports to measure. This objective cannot be attained by any type of capital letter chart.

Auxiliary Advantages.—The following auxiliary advantages of the double-broken circle chart may be noted:

1. At various times we have been requested by members of state, municipal and college health boards and by commercial and industrial companies to give attention to equipment for testing vision. In this respect one important item is the test chart; another is an inexpensive, easily portable chart holder that would be completely glareless and would provide a glareless, well distributed, even illumination of the test chart of a correct and standard intensity. Such a chart holder has been described in a previous paper.[5] The double-broken circle chart described

5. Ferree, C. E., and Rand, G.: A Glareless Illuminated Holder for Visual Acuity Charts with Variable Intensity of Light, Am. J. Ophth. **22**:399-405 (April) 1939.

in the present paper is especially valuable in all places or stations where there is a problem of the accurate and reproducible testing of visual acuity, such as in schools, industrial plants and motor vehicle departments, in the testing of railroad employees, in the commercial air transport service and in the air service of the United States Army and Navy. Among the reasons for this, the following may be noted: (*a*) Customarily in this type of testing no attempt is made at a complete refractive correction. The test of vision must be depended on entirely to indicate the condition of the examinee's eyes, to detect whether the condition is getting worse or better in case there is a refractive defect and to decide whether there is need of reference for a medical examination. There is a poor chance to accomplish a satisfactory result if the conditions of making the test are not standardized and uniform from time to time and from place to place. For example, we find there is great uncertainty at the present time as to just what is normal acuity at different ages. The feeling of uncertainty is due to the fact that it is well known that the conditions of making the test are not the same from time to time and from place to place in examining the same person. Also, if the test conditions are not carefully standardized, one cannot tell in examining a person at different times whether his condition is the same, better or worse. From this it can readily be seen that careful attention to consistency in the testing of vision is more important in the industrial plants, schools and similar places than it is to the ophthalmologist in his routine practice. That is, the ophthalmologist is prepared to make a complete refraction and does not, therefore, have to depend so much on the standardization of his conditions for testing and rating vision. Further, the refractionist's job is to give the best vision it is possible to obtain by means of a correcting glass, providing there are no auxiliary reasons for prescribing otherwise, and in consequence he is not so dependent on what is accepted as the normal rating of vision or on any previous rating he has made. (*b*) There is a great deal of practical and scientific need for knowing what vision is at different ages and what should be considered the norms of vision at these ages, particularly during the formative period and beyond middle life. In this we are personally much interested, and it is one of our strongest motives for trying to secure standardized and correct test equipment. Important means of obtaining a part of this knowledge are the examinations that are made systematically in industrial plants and the schools—grade, high school and college. (*c*) In this more general type of testing vision it is of advantage, too, that the chart serves as a surprisingly accurate and delicate means of detecting the presence of an astigmatism and that the information is gained without additional work and the use of separate and special equipment. As an example of the usefulness of the chart in

this respect and of its sensitivity for the detection of astigmatism, a personnel worker has told us that in using it for the testing of visual acuity he found in a group of 60 persons that a number were wearing weak cylinders when no correction was required; that is, for the size of test object which was their limit of vision they could distinguish only a part of the openings with the cylinder and all of them without it. It is certainly of great advantage to the examiner, whether a nurse, a personnel worker, a layman or even a refractionist, to know when the test of vision is finished that an astigmatism is or is not present.

2. The chart has the following special advantages in the detection and correction of astigmatism: (*a*) The test objects themselves provide a sensitive means for detecting the presence of an astigmatism and a fairly sensitive means of detecting its location. (*b*) Taken collectively, they give great sensitivity to the use of a rotating cylinder in detecting the presence of an astigmatism and in locating its axis, much greater than, for example, test objects of the capital letter type. The extreme sensitivity of the test object both to distortion and to the blurring of its critical details is a factor in this. For example, as already stated, only a slight deviation of the axis of a cylinder from its correct location is needed to cause a detectable change in the appearance of the double-broken circle and of a chart made up of a collection of double-broken circles. (*c*) They also give greater sensitivity in the use of crossed cylinders for this purpose. The great value of the crossed cylinder test in the detection and correction of astigmatism is too well known to refractionists to need any elaboration here.

3. If desired, the number of test objects can be increased by changing the position of rotation of the test chart. For example, the chart can be hung right-side up or upside down; that is, the chart can be hung so that the large test objects are either at the top or at the bottom. This is because of the shape of the test object and the type of task that is set. The change of position of rotation of the test chart merely changes the direction in which the openings in the circles point. For this reversal of position a hanger should be provided at both the top and the bottom of the chart. Further, if so extreme a measure were of advantage, the effective number of test objects could be increased almost indefinitely by changing the position of the test chart into the possible positions through 360 degrees.

4. It is clear that with the double-broken circle chart the possibility of memorizing or, with the exception of malingering, of taking the test in any way but a fair way is completely eliminated; also, the power to discriminate detail could be tested in all possible meridians. To prevent malingering, we know of nothing that can be done in the way of test objects alone.

In conclusion, we urge that the greatest possible care be exercised in the selection of the characters and the construction of the charts which are to be used for the testing of visual acuity. The test objects and test characters, not the projector or other means of presenting them, are the foundation of the test. With charts constructed in a hit or miss fashion—some made up of authentic Snellen letters; some made up of capital letters not constructed to meet even as nearly as could be, the 1-5 minute requirement of the Snellen scale and not of the same order of discriminability in different charts; some made up of other types of test object, and all too often inaccurately constructed as to size—the situation in acuity testing is chaotic. Is it any wonder that in the air service, Army, Navy and commercial, and in many similar fields the complaint is made that tests conducted at different stations and at different times do not give the same rating of acuity? It is a recognition of this situation that leads to the appointment of committees for the standardization of test charts. That these committees have to be appointed over and over again is due largely to the fact that a proper rating scale can never be obtained with capital letters as test objects.

In stating results, must one always be required to give a detailed specification of the kind of chart used or should not the endeavor be made to get a test object and a test chart that best satisfy the requirements of a rating scale and adopt and use them as standard? For the test object we recommend the double-broken circle, the critical details of which, the two breaks in the circle, can be constructed to meet absolutely the 1 minute requirement for such details and the overall size, the 5 minute requirement; the judgment made in terms of the function tested, the power to discriminate detail; and the results evaluated in terms of a correct rating scale.

SUMMARY

The testing of visual acuity is fundamentally a testing of the space function of the eye. It should be one of the most satisfactory tests of human powers we have because of the certainty and regularity of the space function. Instead, it is one of the most unsatisfactory. This is because of the test objects that are used and the lack of control of conditions under which the test is made.

In former papers we have discussed the subject of testing and rating vision broadly. In the present paper it is discussed only with reference to the comparative merits of the capital letter charts and a new chart, the double-broken circle chart, which has recently been made available to the public.

A new method of rating vision, made possible by this chart, is also described, namely, a rating in terms of power to discriminate detail in the four principal meridians of the eye—horizontal, vertical and the two

oblique. This rating is directly in terms of acuity of vision, the function to be measured, not in terms of the power to recognize and name objects; also, it shows whether or not an inequality is present in the different meridians (an astigmatism) and roughly indicates the location.

Capital letter charts are defective in four important regards: the test object, the type of judgment, the construction of the charts and the rating scale. The defects of the capital letter charts are discussed under these headings in the paper.

The letters of the alphabet serve well the purpose for which they were devised, but they are far from being good test objects. For this they are entirely too variable and irregular as to form, gross or overall size and size of the details that have to be discriminated. Obviously the use of a multiplicity of test objects of unequal difficulty, such as the capital letters, presents an insurmountable obstacle with respect to such important points as the type of judgment that can be used and the possibility of reducing to a uniformly graded scale. A proper rating scale can never be obtained with capital letters as test objects. Further, consistency or reproducibility of result cannot be expected from time to time and place to place.

The double-broken circle chart is discussed under the following headings: the test object, the test chart and method of using it, the report of the testee, the rating scale and auxiliary advantages.

This chart has been devised by us to correct the deficiencies found in charts of the capital letter type and to comprise as far as possible all the features that constitute a scientific as well as a practical test of visual acuity. We have found it to serve this purpose exceptionally well. With it vision can be rated in a correctly graded scale by the method noted earlier, namely, in terms of power to discriminate detail in the most important meridians of the eye, and when it is used with proper control of illumination and the other variable factors noted in the paper high reproducibility and consistency of results can be obtained from time to time and from place to place.

STUDIES IN CONVULSANT THERAPY

IV. THE EFFECTS OF METRAZOL (PENTAMETHYLENETETRAZOL) ON THE EYE

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So far-reaching have been the results of metrazol convulsant therapy in recent psychiatric practice that it now seems essential to investigate this interesting drug in its relation to some of the other branches of medicine. The purpose of this report, fourth in a series of studies associated with convulsant therapy, is to compile a detailed record of the effects of metrazol on the human eye. Some of these effects, as seen during the usual course of intravenous injections of metrazol, have already been noted briefly in the literature; others, especially the local effects resulting from instillation of the drug into the conjunctival sac, are original observations which, as far as known, have not been hitherto described.

In order to examine the ocular phenomena of metrazol in their proper perspective, the reader should know something of the nature of the drug, technic of administration and associated clinical phenomena. These have been more fully described in previous papers [1] but will be reviewed briefly here. The reader is also referred to the comprehensive thesis and bibliography recently published by Harris.[2] Pentamethylenetetrazol (known in this country as metrazol and abroad as cardiazol) was synthesized by Prof. K. F. Schmidt and his co-workers [3] in an attempt to produce a water-soluble substance having the therapeutic

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From the Fairfield State Hospital.

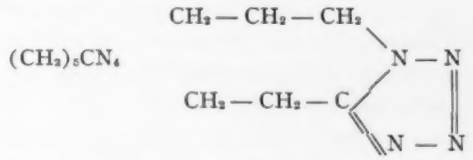
Read in part at the Thirtieth Annual Meeting of the American Psychopathological Association, Cincinnati, May 19, 1940.

1. Dean, S. R.: Studies in Convulsant Therapy: I. Technique and Clinical Phenomena, J. Connecticut M. Soc. **2**:325-330 (July) 1938; II. The Role of Alkalinization, J. Lab. & Clin. Med. **24**:256-259 (Dec.) 1938. Moore, C. D., and Dean, S. R.: Studies in Convulsant Therapy: III. Treatment of Long-Standing Functional Psychoses with Metrazol; Results and Theory of Action, J. Connecticut M. Soc. **3**:338 (July) 1939.

2. Harris, A.: Cardiazol Treatment of Schizophrenia, J. Ment. Sc. **84**:735 (Sept.) 1938.

3. Schmidt, K. F.; Hildebrandt, F., and Krehl, L.: Ueber "Cardiazol," ein in wässeriger Lösing subcutan injizierbares neues Analepticum, Klin. Wchnschr. **4**: 1678 (Aug. 27) 1925; cited by Harris.[2]

properties of camphor without its disadvantages of insolubility and toxic effects. Its structural formula follows:



This drug, hereafter referred to as metrazol, is a white, crystalline, faintly bitter, practically odorless powder, with a melting point of 58 to 59 C. It is freely soluble in water, up to a 50 per cent solution being possible without decomposition. It belongs to the class of substances known as analeptics, which stimulate the vasomotor and respiratory systems when they are in a depressed state. For that purpose, when injected slowly in doses of 1 to 3 cc., it is of value as a restorative in circulatory collapse, shock and respiratory distress. In larger doses, however, especially when injected rapidly into the blood stream, it acts as a powerful convulsant, and it is with that property that psychiatry has been concerned as a result of von Meduna's investigations.[4]

The characteristic result of a convulsant dose of metrazol—a reaction that occurs with almost predictable constancy—is (1) an immediate, (2) single, (3) self-limited convulsion that seems to be (4) practically identical with the grand mal paroxysm of idiopathic epilepsy.

In typical cases the following phases may be observed: (1) aura, manifested by coughing, sighing, lip smacking, blinking of the eyes or screaming; (2) a precipitating phase, consisting of irregular, jactitating movements; (3) a tonic phase, characterized chiefly by loss of consciousness, cessation of respiration and generalized muscular spasm or rigor; (4) a clonic phase, in which the tonic spasm gives way to rhythmic clonic contractions (the tonic and clonic phases [convulsion proper] last a minute or less); (5) a recovery phase, manifested by cessation of the paroxysm and resumption of respiration: (6) an autonomic phase, during which the patient exhibits psychomotor restlessness and gradually regains consciousness, and (7) a period of sleep, from which, after an interval of several minutes, the patient awakens ready to resume his usual activities, with perhaps a slight residual clouding of consciousness that may last for a few hours and with amnesia for the attack.

If the dose of metrazol is insufficient to produce a convulsion, a petit mal reaction may result. This consists of any of the manifestations of the aura or precipitating phase short of the loss of consciousness.

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4. von Meduna, L.: Die Konvulsionstherapie der Schizophrenie, Halle, Carl Marhold, 1937.

OCULAR PHENOMENA

In addition to the aforementioned signs, various ocular phenomena occur with such frequency as to merit separate description and recording. The following phenomena do not all occur in every instance but are rather a composite picture of the findings that may be observed in a large series of persons treated with metrazol.

Preconvulsive Period (Aura and Precipitating Phase).—Visual hallucinations, often in common with olfactory and gustatory types, occur frequently and with much variation. They are usually best remembered and described during a petit mal attack, when they may give rise to terrifying sensations; occasionally, however, a patient who has had a grand mal attack recalls various visual sensations that preceded the loss of consciousness.

In their simpler presentations the hallucinations consist of unformed photomas, described as flames, clouds, sparks and flashes of light in linear, oval, zig-zag or star shapes. They may be kinetic (moving or flying) or static (motionless). Chromatopsias are common, especially xanthopsia; also sensations of everything turning black. Friedman, in one of his papers, also mentioned the occurrence of varicolored visual hallucinations.[5]

Less frequently one encounters formed visual hallucinations, apparently generated by the metrazol and not a manifestation of the patients' everyday psychotic experiences. Such presentations may be closely allied to reality or may consist of complex visual agnosias and metamorphopsias. Thus, a patient saw himself transformed into a dog. A male patient beheld himself as a female. Another experienced lilliputian hallucinations (micropsia), stating that each time he received an injection diminutive figures of Christ appeared on his chest. Still another described brobdingnagian hallucinations (macropsia), stating that after an injection all objects about him rapidly expanded coincidentally with a bursting sensation in his own head. Harris [2] mentioned a patient who had the sensation that all the persons in the room were rushing toward her, growing bigger and towering over her. The constancy with which a given hallucinatory pattern is repeated in each case suggests that the same area of the brain is stimulated with subsequent injections.

At times pupillary changes may be initiated in the preconvulsive period. Thus, the pupils may begin to dilate even before the onset of coma. As a rule dilation is progressive throughout the tonic-clonic sequence, but occasionally mydriasis has been observed to be maximal

5. Friedman, E.: Irritative Therapy of Schizophrenia, New York State J. Med. **37**:1813 (Nov. 1) 1937.

from the start. If the reaction to metrazol comes to an end at the precipitaing phase, the pupils may exhibit hippus before regaining their normal size.

Convulsive Period (Tonic and Clonic Phases).—The most constant but by no means invariable manifestations occur during these two phases. At the onset there is an intense blepharospasm corresponding to the generalized tonic spasm and later becoming intermittent during the clonic phase. If, after a while, the eyelids are forced open, one may observe mild injection of the posterior conjunctival vessels, diminishing from the periphery toward the limbus. This is apparently not due to any chemical action of metrazol on the blood vessels but is a mechanical effect resulting from pressure on the eyeball of the tightly contracted lids.

Because of the blepharospasm the presence or absence of the wink reflex cannot be determined; however, it is evident that conjunctival and corneal reflexes are lost from the immobility of the eyeball when those areas are stimulated.

If the pupils have not dilated in the preceding phases, they do so now, and mydriasis becomes progressive as the paroxysm continues. At the same time the light reflexes and ciliospinal reflex are abolished. That mydriasis is neurogenic and not asphyxial is established by the fact that it may occur before or coincidentally with the onset of apnea and the loss of consciousness.

Ophthalmoscopic examination of the fundi at this time or later reveals no apparent changes in the caliber of the retinal vessels, a fact also mentioned by von Meduna.[4]

The position that the eyes assume is interesting. Frequently there is conjugate deviation in a horizontal or vertical direction. Reese and his co-workers [6] stated that the eyes turn up, usually to the left facing the predominant hemisphere, but Low and his co-workers [7] found no preference for either the left or the right side. On 47 occasions they noted that the eyes turned 7 times to the right, 9 times to the left, 13 times to the right and upward and 14 times to the left and upward, whereas on 4 occasions the deviation was straight upward without a noticeable right or left component; also at times the deviation was to one side at the beginning of the paroxysm and subsequently swung to the opposite side. My own observations agree roughly with these, and

6. Reese, H. H.; Vander Veer, A. H., and Wedge, A. H.: The Effect of Induced Metrazol Convulsions on Schizophrenic Patients, J. Nerv. & Ment. Dis. **87**:570-583 (May) 1938.

7. Low, A. A.; Sonenthal, I. R.; Blaurock, M. F.; Kaplan, M., and Sherman, I.: Metrazol Shock Treatment of the "Functional Psychoses," Arch. Neurol. & Psychiat. **39**:717-736 (April) 1938.

Cook [8] mentioned a similar variability. It should be mentioned that rarely one observes a convergent strabismus of one eye; however, bilateral convergent, divergent or skew deviation have never been reported.

Sorger and Hofmann [9] stated that the eyes always deviate in the same direction in each patient and that contralateral motor manifestations occur, such as the loss of the patellar reflex on the side opposite that of deviation. If this is true, the direction of deviation might be an important clue as to which side of the brain was being stimulated, and I therefore made careful observations with that point in mind. However, I was unable to establish any relation between the direction of deviation and that of reflex motor phenomena. When the latter occurred, they were in the great majority of cases bilateral and could be elicited only in the postconvulsive period, usually after the eyes had moved from their position of original deviation.

Postconvulsive Period (Recovery Phase, Automatic Phase and Period of Sleep).—The tendency in this period is for a restitution of all manifestations in a normal direction. The process, however, is far from being uniform in all cases. In general, the eyes are open at the end of the clonic phase, with fleeting widenings of the palpebral fissures corresponding to the other automatic movements of the body. Anesthesia of the conjunctiva and cornea usually persists for several minutes. With beginning consciousness, the light reflexes and ciliospinal reflex reappear. The pupils may contract with the first inspiration or more gradually. Georgi and Strauss,[10] with whom my own observations agree, stated that in the interval between the first inspiration and the recovery of normal pupillary function one often sees alternate constriction and dilatation under constant illumination (hippus). They called attention to the similarity of pupillary changes in convulsions due to metrazol and spontaneous epilepsy and urged further investigations of this topic.

Where conjugate deviation has occurred in the preceding phases, the eyes may now return promptly to a normal position, or else the movements may show a characteristic graduation in progress to normal

8. Cook, L. C.: Cardiazol Convulsion Therapy in Schizophrenia, Proc. Roy. Soc. Med. **31**:567-577 (April) 1938.

9. Sorger, E., and Hofmann, E.: Beobachtungen und Ergebnisse bei der Cardiazol-Krampfbehandlung der Schizophrenie, Psychiat.-neurol. Wchnschr. **39**: 462-465 (Oct. 9) 1937.

10. Georgi, F., and Strauss, A.: Krampfproblem und Insulintherapie: II. Besondere Berücksichtigung des von Meduna angegebenen Verfahrens, Schweiz. Arch. f. Neurol. u. Psychiat. (supp.) **39**:55-64, 1937; translated, Am. J. Psychiat. (supp.) **94**:76-89 (May) 1938.

consciousness. Birkmayer,[11] who has devoted a paper to the subject of ocular movements during convulsions due to metrazol, described the following varieties: slow, smooth, dissociated ocular movements; slow, smooth, lateral conjugate deviation; compensatory movements elicited by drawing the head to one side, in a direction similar to that in spontaneous deviation; compensatory movements followed by secondary deviations in the direction in which the head is drawn (e. g., when the head is moved toward the right, the eyes first move to the extreme left, then return right slowly to the midline); slow, smooth, conjugate movements in the whole visual space; occasional small, quick nystagmiform jerks in the course of these slow excursions or during a moment of quiet. Birkmayer recognized two basic types of movement: (1) the slow, smooth, regular movements that appear first and (2) the quick, jerky types that appear only toward the end at about the time of complete resynthesis of consciousness. He expressed the belief that the former are to be attributed to the vestibular system, being responses to acoustic stimuli, and are to be defined as passive adjustment to the environment; the latter are active, leading to cognizance of the environment.

Finally, it may be mentioned that studies of visual acuity and perimetric studies of visual fields show no changes in those components, even after courses of twenty-five to thirty convulsions.

Although not an ocular manifestation, in the strict sense of the word, alexia may also be included here for the sake of completeness. Alexia (word blindness) may be elicited during the postconvulsive period, varies in duration in different persons and is allied to other aphasic disturbances that appear in the course of reintegration of consciousness.

LOCAL ACTION

The prevalence of ocular manifestations during the convulsion induced by metrazol naturally aroused my curiosity with respect to its local effects on the eye. It seemed to me that studies in that direction should yield information regarding any predilection that metrazol might have for either the sympathetic or parasympathetic components of the autonomic nervous system. Accordingly, serial observations were conducted on 20 patients in whom preliminary examination revealed no evidence of an ocular pathologic process. Aqueous solutions of metrazol were used in strengths varying from 1 to 10 per cent. Although all of these concentrations produced in some degree the changes that I

11. Birkmayer, W.: Beobachtungen über Augenbewegungen im Cardiazolkrampf, Arch. f. Psychiat. **109**:512-524, 1939; abstracted by the Science Library of the Neuro-Psychiatric Institute of the Hartford Retreat, ser. 7, no. 139, June 24, 1939.

am about to describe, these changes were most characteristic and constant when the 10 per cent solution was employed; consequently, that concentration was used in most of the experiments. At five minute intervals a drop of the solution was instilled into one eye of each patient, the other eye serving as a control. The results were found to be of two types: mechanical and neurogenic. The first will be described merely for the sake of completeness; it has no particular significance. It is with the second that I shall be chiefly concerned.

Mechanical Effects.—A solution of metrazol, especially in the higher concentrations, is rather irritating, and the initial effect is a sharp, stinging sensation that lasts about thirty seconds. It is followed by a brief period of lacrimation, slight photophobia and later a slight mucoid discharge. The conjunctival blood vessels become engorged, and on eversion of the eyelids the mucous membrane is red and a little swollen. That this engorgement is a direct result of the counterirritant action is indicated by the fact that the ophthalmoscope reveals no similar changes in the vessels of the fundi. All of these counterirritant manifestations subside completely within a half hour after the last drop is instilled. Corneal transparency is at no time affected, and there is no diminution of corneal and conjunctival reflexes.

Neurogenic Effects.—When a neurotropic drug is instilled into a healthy conjunctival sac, it will be carried by the blood vessels and lymphatics at the sclerocorneal junction into the iris and ciliary muscle, where it acts directly on the nerves and ganglions of these structures. This may also be assumed to apply to metrazol.

When metrazol is instilled it produces a characteristic dilation of the pupil, which begins in about fifteen minutes and reaches its height in another fifteen minutes—thirty minutes in all. At that time the pupil is about three-quarters dilated, and it does not proceed beyond that point even when more drops are added. Mydriasis then continues for about one and one-half hours, after which the pupil contracts gradually until it regains its normal size. As the latter process consumes another hour and a half, the total duration of mydriasis is approximately three hours.

Reaction to accommodation in the dilated pupil is diminished but not absent, and the same is true of the reaction to light, especially when a flashlight is used. In some patients the reaction to flashlight almost disappears. The reaction to strong daylight, however, still remains, and it is therefore best to make the preliminary observations in a shaded light, where the differences in the size of the test pupil and control pupil become obvious.

To recapitulate, metrazol produces an incomplete mydriasis lasting about three hours, and decreases, but does not abolish, the light and

accommodation reflexes. In these respects its action is reminiscent of that of benzedrine sulfate, as described by Myerson and Thau.[12] Unlike benzedrine, however, it does not seem to increase intraocular tension or to widen the palpebral fissure.

An incidental finding that may be of some interest is that when a pupil has been dilated locally with metrazol and the same patient is then given sufficient metrazol to produce a convulsion, an additive effect is produced, resulting in additional dilatation of the test pupil as compared with the control.

In order to obtain further information on the automatic mechanism of the mydriasis caused by metrazol, the following experiments were conducted: After a pupil had been dilated by metrazol, a 1 per cent solution of pilocarpine (a cholinergic substance, i. e., a parasympathetic stimulant) was instilled. Constriction of the pupil began quite promptly, and the effect of the metrazol was abolished within a half hour. As a corollary, when the pupil was first constricted with pilocarpine, metrazol was unable to effect mydriasis. The significance of these observations will be discussed in another part of the paper.

EFFECT OF METRAZOL ON THE ARGYLL ROBERTSON PUPIL

Douglas Argyll Robertson described the classic pupillary syndrome that bears his name in 1869, but it has not yet been produced experimentally, and its mechanism is still controversial. The chemical approach to the problem has yielded some interesting, even if not very enlightening, observations. Recently Myerson and Thau [12] reported the effects of benzedrine sulfate. They found that the drug caused the Argyll Robertson pupil—i. e., a pupil which is miotic, which does not react to light and which reacts in accommodation—to dilate, enlarge in darkness and contract with difficulty in reaction to flashlight but more readily in reaction to daylight.

This report prompted me to repeat the experiment with metrazol. Two patients with syphilis of the central nervous system presenting Argyll Robertson pupils were observed. Exactly the same procedure was followed as in the case of patients with normal eyes (described previously). Within fifteen minutes after the solution of metrazol was instilled, the test pupil began to dilate, and in thirty minutes the dilatation had reached a stage beyond which it proceeded no further. At that stage the pupil was about half way dilated, the effect being definitely less than in a normal pupil. No additional mydriasis occurred in darkness, nor was there any constriction in reaction to flashlight or bright day-

12 Myerson, A., and Thau, W.: Human Autonomic Pharmacology: IX. The Effect of Cholinergic and Adrenergic Drugs on the Eye, Arch. Ophth. **18:** 78-90 (July) 1937.

light. In short, metrazol produced incomplete dilatation but no other observable changes in the Argyll Robertson pupil.

Parallel experiments with 1 per cent solution of atropine sulfate resulted in greater dilatation (but never complete mydriasis) than in the case of metrazol. Moreover, if a solution of atropine was applied to an Argyll Robertson pupil previously dilated with metrazol, an additive effect occurred, so that the resulting dilatation was greater than that with metrazol alone.

COMMENT

The study of chemical mediation of the nervous system has intrigued investigators for many years and has resulted in the elaboration of much of the knowledge with respect to the functions of various divisions of that system. The search has been especially keen for evidences of specificity and has given rise to such designations as sympathomimetic (adrenergic) and parasympathomimetic (cholinergic) substances. Actually, however, no neurotropic drug exhibits 100 per cent specificity, the distinction being merely one of degree. This is no less true of metrazol. Correlation of the effects of this drug with the known physiology of the nervous system has yielded some interesting deductions with respect to its theater of action; this will be the subject of another paper. For the present, suffice it to say that metrazol stimulates all the components of the nervous system, though not in equal degree. Thus, in the case of the autonomic division it is obvious that sympathetic manifestations overshadow parasympathetic, a conclusion also reached by Gellhorn and Darrow [13] in their paper devoted to the action of metrazol on the autonomic system. This is especially evident in the case of the eye, in which mydriasis occurs both as a remote and as a local sign; in cats, retraction of the nictitating membrane, as described by Gellhorn and Darrow,[13] provides further corroboration.

In arriving at the conclusion that the mydriasis produced by the local application of metrazol is the result of stimulation of the sympathetic nervous system, I have applied the classic theory of the innervation of the iris, namely, that the size of the pupil is a balanced function, the resultant of a tonic equilibrium between sympathetic and parasympathetic impulses. Assuming this to be true, mydriasis may be produced in one of two ways—by paralyzing the parasympathetic innervation or by directly stimulating the sympathetic innervation. The action of atropine is a classic example of the first. It is a cycloplegic rather than a mydriatic, since it produces its effect by paralyzing the constrictor pupillae (abolition of reaction to light and to cholinergic substances).

13. Gellhorn, E., and Darrow, C. W.: The Action of Metrazol on the Autonomic Nervous System, Arch. internat. de pharmacodyn. et de thérap **62**:114-128 (May 31) 1939.

Metrazol, on the other hand, seems to be a true mydriatic; that it leaves the parasympathetic innervation intact is evidenced by the fact that the dilated pupil can still be stimulated by light and by a drug like pilocarpine; it must, therefore, produce its mydriasis by directly stimulating the sympathetic innervation.

This adrenergic action of metrazol on the pupil suggests that parallel studies be made on other organs. Investigations are already in progress at this clinic on the effect of the drug on the nasal mucous membrane. Its action on the gastrointestinal tract, urinary bladder and other autonomically innervated viscera also deserves careful study.

It is not my intention at this time to present a detailed discussion of the effect of metrazol on the Argyll Robertson pupil. I have not been able to derive any positive conclusion from the experiment and have mentioned it here merely for whatever interest it might possess.

SUMMARY

Various ocular manifestations are common features of the metrazol paroxysm. These consist of the following groups:

(*a*) Psychic: visual hallucinations; alexias.

(*b*) Motor: blepharospasm; blepharoclonus; conjugate deviations; nystagmoid movements.

(*c*) Sensory: abolition of corneal, conjunctival, ciliospinal, and light reflexes.

(*d*) Autonomic: mydriasis; hippus; retraction of nictitating membrane.

Metrazol stimulates all the components of the nervous system, but in the autonomic division sympathetic manifestations overshadow parasympathetic. Preponderance of sympathetic manifestations is especially evident in the autonomic reactions of the eye.

When metrazol is applied locally to the eye it acts adrenergically; i. e., it produces mydriasis by direct stimulation of the sympathetic nervous system, leaving the function of the parasympathetic nervous system (constrictor) intact.

Metrazol produces partial dilatation of the Argyll Robertson pupil, but does not restore its reaction to light.

ACUTE HYDROPS OF THE CORNEA COMPLICATING KERATOCONUS

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Although the literature on keratoconus is voluminous, reports of acute ectasia occurring in the course of the disease are relatively rare. Such reports as are available in the literature are recorded under the title of acute ectasia, although ectasia is not always marked nor is it always present. The bulging of the cornea, its increase in depth and the opacity of the stroma are all due to its invasion and water-logging by the aqueous humor, and for this reason we feel that the term "acute hydrops of the cornea" is more definitely descriptive of this complication of keratoconus. The opportunity to study such a case and to record the progressive steps in the condition by photography and drawings impel us to publish this report in order to provide some encouragement for patients and oculists who may at some future date face this alarming complication.

Duke-Elder stated that this condition "is the result of a rupture of Descemet's membrane and its endothelial lining, which is immediately followed by an opacification and swelling of the corneal tissues due to the entrance of aqueous into the stroma. As soon as the endothelium regenerates, the cornea regains its original appearance although some new opacity may remain. The ectatic portion usually is confined to the central part of the cornea and rarely involves more than half its area, the apex of the curve being eccentrically placed somewhat downwards and nasally." Appelbaum, in an extensive review of the subject of keratoconus, offered a similar explanation as the cause for the complication of ectasia. Neither author speculated as to whether rupture of Descemet's membrane is due to increased pressure in an abnormal eye or whether the tissue is diseased or sensitized due to endotoxins.

Berner recently reported such a case and reviewed the literature completely, his bibliography containing 6 previous reports by Terrien,

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Rabinovich, Cooke, Reid, Rollet and Goulden. The end result in some of these cases was not as satisfactory as that experienced in his own case in which paracentesis was done daily for four days, accompanied by the application of a 1 per cent solution of formaldehyde to the apex of the ectasia in order to produce a resistant scar.

Terrien in 1906 protected the cornea in his patient, a woman aged 43, by a median tarsorrhaphy, noting regression of the staphyloma as well as of the corneal opacity. Visual acuity returned to 6/60, the same as was recorded before the hydropic invasion of the cornea. His impression of the production of the complication was that rupture of the endothelium and Descemet's membrane was followed by an imbibition of aqueous by the corneal stroma. His description of the clinical appearance of the cornea at the onset of the condition was exactly that observed in our patient.

Rabinovich in 1908 described an acute transitory ectasia complicating keratoconus in which recovery ensued, but the treatment was not described.

Cooke presented before the Royal Ophthalmic Society in 1911 a man, aged 28, who had suffered this complication of conical cornea. An elliptic portion of cornea, 3 by 6 mm., was excised from the outer portion of the vertical diameter of the ectasia, and healing progressed satisfactorily. Visual acuity improved from 6/60 to 6/18.

Reid reported a similar case before the same society in 1924. The cornea of his patient, a youth of 18, was globate rather than ectatic. Treatment consisted of an inverted T-shaped incision at the lower part of the cornea with drainage of the aqueous; the corneal opacity steadily decreased in area, and vision improved from 6/60 to 6/18.

Rollet in 1929 gave the first complete report with observations made on slit lamp examination, showing that the thickening of the cornea took place in the substantia propria. He performed sclerectomy on his patient, a girl of 18 years. The corneal staphyloma was reduced, and clearing of the cornea took place.

Goulden's case was one of keratoconus accompanied by descemetocele and does not seem to meet the requirements for inclusion in this series of cases of acute hydrops.

A search of the literature, in addition to the foregoing reports gathered together by Berner, yielded but 2 other case reports. Butler in 1932 reported a case of acute conical cornea with thickening due to hydropic invasion which was accompanied by the curious formation of a bleb on the posterior corneal surface. The hydropic opacity, bleb and thickening of the cornea all disappeared after eight months, but vision was reduced to perception of light. Apparently the visual loss

was due to some cause other than corneal opacity. No treatment had been given during the course of the acute stage.

Rugg-Gunn presented before the Royal Society of Medicine in 1935 a patient of Dr. Stutterheim, of Johannesburg, South Africa, who had keratoconus with a visual acuity of 4/60 in the right eye and 3/60 in the left eye. Several years later he suffered acute transitory opacity of both corneas. Under treatment, the bulging had subsided, but an opacity persisted. The treatment was not described, but apparently it was medical only. The patient was fitted comfortably with contact glasses, with which he obtained a visual acuity of 6/12 in the left eye and 6/18 in the right eye.

Berner's case, reported in 1936, was that of a girl aged 14 years, in whom acute hydrops and true ectasia suddenly developed, following a game of basketball in which there had been no direct trauma to the eye. Paracentesis performed for four consecutive days was effective in reducing the ectasia. Clearing of the cornea resulted, and with a contact glass the final visual acuity of 6/9 was obtained.

REPORT OF A CASE

B. A., a white man, was first seen by one of us (D. B. K.) on June 13, 1927, when he was 26 years of age and a medical student in New York. His chief complaint was failing vision for the past four years. He had been wearing a + 1.00 sph. ⌒ — 2.75 cyl., ax. 75 on the right eye and a — 0.75 sph. ⌒ — 1.75 cyl., ax. 15 on the left eye. He accepted for the right eye a + 1.25 sph. ⌒ — 5.50 cyl., ax. 75, and for the left eye a — 0.75 sph. ⌒ + 3.00 cyl., ax. 10. With this correction, vision was 20/20 in each eye. Because of the irregular astigmatism which was detected with the aid of the keratometer and because of the increasing astigmatism, the diagnosis of early keratoconus was made.

On July 14, 1928 a progressive change was again noted. The patient accepted for the right eye a + 2.50 sph. ⌒ — 6.50 cyl., ax. 70, and for the left eye a — 1.00 sph. ⌒ + 3.50 cyl., ax. 10. With this correction, vision in the right eye was 20/40 + and in the left eye 20/30. In 1930 Zeiss contact glasses of regular curvature were tried; for the right eye a 7.1 mm. corneal curvature combined with a — 4.50 sph. gave vision of 20/20 —, while for the left eye an 8.1 mm. corneal curvature and no accessory lens gave vision of 20/20 —. No record of the scleral curve was made. He accepted a + 4.50 sph. ⌒ — 8.00 cyl., ax. 85 for the right eye and a + 4.00 sph. ⌒ — 8.00 cyl., for the left eye. With this correction vision was 20/30 + in each eye. At this time the diagnosis of keratoconus was easily confirmed by the clinical appearance of the conical cornea and by the pulsation of the apex of the cone as detected with the keratometer. The regular Zeiss ground contact glasses were not tolerated, but after numerous trials Müller blown glasses were found from a large stock of lenses supplied by a New York firm which were suitable for each eye and which were worn with satisfaction for fairly long periods. The patient became adept in handling them.

In April 1933 he wrote as follows: "No matter in what work I may engage, I am dependent on contact glasses as I have no working vision without them. I wear a glass in only one eye at a time, alternating eyes each day. I wear the

glass continually for eight hours to nine hours without any discomfort, and then after a rest period of about two hours while at dinner I can use the glass again for two or three hours in the evening, or, if the occasion demands, I can wear the glass in either one eye or the other for a period of fifteen to sixteen hours."

Three complete investigations of the general condition were made in the effort to discover the cause of the development of the keratoconus. The results were inconclusive and may be summarized as follows: There was no history of relevant ocular disease in the patient's family. He never ate vegetables or fruit as a child and eats very little of them now. He had always ingested sufficient quantities of meat, milk and eggs. He had pneumonia without complications at the age of 3. He had frequent attacks of epistaxis, but cauterization stopped them. He had measles and had undergone a tonsillectomy at 28 years of age. Physical examination revealed that he was a well developed and nourished man of stocky short frame, with profuse hair on the chest, abdomen and extremities. The sexual development was normal, with no evidence of glandular deficiency, except for his short stature and a basal metabolism rate which was usually minus, averaging — 18 per cent. He had had extensive dental caries and many fillings. His blood pressure was 114 systolic and 72 diastolic. Laboratory examination of the blood revealed a hemoglobin content of 95 per cent, 5,620,000 red blood corpuscles, 4,400 white blood cells, 72 per cent polymorphonuclears and a normal smear. Urinalysis showed a specific gravity of 1.008; an acid reaction and an absence of albumin and dextrose. Microscopic examination gave negative results. The phthalein excretion was 60 per cent. Concentration tests showed the following specific gravities: 1.018, 1.020, 1.021, 1.022 and 1.024. Dextrose tolerance tests gave the following values for blood sugar: 100.1, 150.1, 202, 155 and 142 mg. per hundred cubic centimeters. The Wassermann reaction of the blood was negative in both antigens. The Kahn reaction was negative. Chemical analysis of the blood showed calcium, 10.9 mg. per hundred cubic centimeters; phosphorus, 4.3 mg. per hundred cubic centimeters; chlorides, 6.44 Gm. per liter; serum protein, 7.25 per cent; creatinine, 1.5 mg. per hundred cubic centimeters; cholesterol, 0.238 per cent; urea, 0.29 per cent, and uric acid, 3.95 mg. per hundred cubic centimeters. The carbon dioxide–combining power of the blood was 59.8 volumes per cent. The basal metabolic rate was — 18 per cent. Stereoroentgenograms of the chest were normal. There was no evidence of a persistent thymus.

In summary, up to 1936, a case of keratoconus was studied for a clue as to causation and treatment. The results of all tests were within normal limits. A history suggesting vitamin deficiency was obtained. On this basis a diet high in vitamin content was recommended for trial.

In 1933 the first deep opacity developed in the left cornea. Between 1933 and 1936 several other opacities formed in each cornea. These may well be interpreted as minor ruptures of the endothelium and of Descemet's membrane, with rapid healing and with relatively minor symptoms and signs of change in the course of a case of progressive keratoconus. The use of the contact glasses probably did not produce the ruptures by trauma, as this patient was careful in their use.

During the summer of 1936 the patient was in Memphis, and he wore his contact glasses every day. The right one had been worn on the day preceding the episode to be reported for a total of eight hours. At 4 o'clock on the morning of August 22 he was awakened by a slight pain in the right eye. Immediate inspection in a mirror by him showed an opacity involving practically the entire right cornea. Vision was reduced to perception of hand movements. The feeling

of discomfort in the eye persisted for four hours. He had been swimming the previous evening, but there had been no diving or any strenuous exertion in the water.

As the episode occurred on a week-end, it was thirty-eight hours later before he was seen by one of us (R. O. R.). The appearance of the cornea was that of an acute ectasia, as illustrated by Munson's sign in figure 1. Munson's sign has been admirably illustrated and described in Appelbaum's review and is a definite aid in the diagnosis of keratoconus. With the examiner in front of the patient and with the upper lids raised, the patient is directed to look downward until the free margin of the lower lid bisects the cornea horizontally. The angle thus formed in the margin of the lid becomes a measure of the angle of the apex of the conical cornea. This ectasia was gray and globate and involved the central 8 mm. The eyeball showed a faint ciliary flush, but nothing in proportion to the corneal changes. These consisted of a disccid opacity with sharp outlines involving all layers of the cornea, the total depth of which was one and a half to two times that of the left eye. This could be differentiated into a central anterior

Fig. 1.—Munson's sign illustrating acute ectasia complicating keratoconus in the right eye. A contact lens obscured keratoconus in the left eye.

striate opacity similar to that in the apex of the left cornea, a deeper translucent grayness of the substantia propria, which accounted for the increased corneal depth, and posterior to this, some broad vertical and oblique lines of steely, gunmetal relucency which were interpreted as folds or breaks in Descemet's membrane. A light pressure bandage was applied, and a drop of a 0.25 per cent solution of physostigmine salicylate was instilled every four hours.

Reasoning that this acute phase was due to rupture of Descemet's membrane and the endothelium with edema of the stroma and that lowering the tension would aid in regeneration of the endothelium over the breaks in Descemet's membrane, paracentesis was done, and repeated twice daily, by inserting a spatula through the conjunctival tunnel into the anterior chamber. The ectasia, which measured by the exophthalmometer was 0.5 to 1 mm. in advance of the apex of the left cornea, receded a full millimeter after each paracentesis but made no permanent regression. After a week of such management ciliary injection developed and the eye became painful, whereupon atropine was prescribed, with prompt relief of symptoms. At this time the evacuated aqueous contained some fibrinous threads.

Drainage of the anterior chamber continued until September 7, when it became necessary for the patient to go to his home in the West because of the illness of his father. He was seen there by several consultants, and as the paracentesis had become a painful procedure, he decided to dispense with the treatment. It had been done a total of twenty-six times.

Fig. 2.—Front view of the right eye of the patient in the reported case of acute hydrops of cornea complicating keratoconus.

Fig. 3.—Right eye of the same patient (side view). Note the ectasia of the superior temporal portion of the cornea.

On his return to Memphis a week later no change in the corneal opacity could be detected. Treatment consisting of instillations of atropine and ethylmorphine hydrochloride and the use of hot applications and a light pressure bandage was continued, but no further surgical measure was attempted or given serious consideration. General physical examination disclosed no abnormality save a lowered metabolism, for which during the previous two years he had continued to take thyroid extract, 1 grain (0.065 Gm.) per day. Dental examination disclosed

much pathologic involvement, including pyorrhea, Vincent's infection and devitalized and abscessed teeth. It was deemed advisable by his dentist, because of the severity of the Vincent's infection, to give considerable sodium cacodylate intravenously before attempting extraction.

On September 22, having finished his work in Memphis, the patient left for New York to return to Dr. Kirby's care.

On the admission to the Institute of Ophthalmology, the diagnosis of keratoiritis complicating rupture of Descemet's membrane and ectasia of the cornea was confirmed. The water-logging of the corneal stroma and the inflammatory reaction because of focal infection in the mouth seemed to be the most important features. Nonspecific protein therapy in the form of intramuscular injections of boiled milk was given. The infected teeth were carefully and gradually removed to avoid any focal reaction in the eye. Local treatment consisted of the use of atropine and hot compresses. The grayish white opacity and the increase of the cornea to two or three times its average thickness did not change much for a long time. Apparently it takes quite a while for a major breach of the endothelium and of Descemet's membrane to heal. Perhaps the presence of focal infection sensitizing the tissues and producing keratoiritis delayed the healing of the rupture.

The patient remained in New York for about a month and returned to his home, where the treatment consisted of the application of hot packs to the eye for ten to fifteen minutes twice daily. This was maintained with diminishing regularity for a year. After that they were used two or three times a week for another six months. One drop of 10 per cent solution of ethylmorphine hydrochloride was instilled each night for a year, then replaced by a drop of glycerin in boric acid solution, and these were later alternated in successive months.

The patient was again in Memphis during the summer of 1938 and was repeatedly studied from July 8 to September 3. Remarkable clearing of the cornea had taken place. The remaining opacity consisted only of the subepithelial central opacity of the apex present at the first examination and some translucent posterior lines in Descemet's membrane, consisting of a vertical spindle with horizontal and apical branchings. The cone had entirely disappeared, and an actual flattening of the cornea had developed. The diameter of the cornea had not changed, but the radius of curvature had definitely been altered. This was evidenced by the shift in the refraction.

Vision in the right eye was 6/60, and the patient was able to read Jaeger's test type 16; vision improved with a $+12.00$ sph. $\bigcirc$ $+5.00$ cyl., ax. 120 to 6/9 +; with the addition of a $+1.00$ sph. the patient could read Jaeger's test type 1 easily. Vision in the left eye was 6/30 with a contact glass, and the patient could read Jaeger's test type 1; vision improved with a -1.00 sph. $\bigcirc$ $+3.00$ cyl., ax. 105 to 6/9 (partly). The correction for the right eye was prescribed in ordinary lenses, and in a letter written on Nov. 3, 1938 the patient stated: "I am getting along fine, and it is a wonderful thing to be no longer dependent on a contact glass for reading and ordinary working vision." The change in the refraction was remarkable.

On the night of November 11 the patient experienced in his left eye the same interesting phenomenon that had occurred two years previously in his right eye, namely, bulging and opacification of the left cornea. He did not have a paracentesis done at this time, preferring to carry on some experimental work on his own initiative. Treatment has consisted of the application of hot packs regularly twice daily and, after a month, the daily instillation of 1 drop of 5

per cent solution of ethylmorphine hydrochloride. Vision was reduced to perception of hand movements at a few inches, but after three months clearing began with visual improvement. The acute bulging of the cornea had also decreased at that time. No iritis occurred at any time, and it is possible that repeated paracenteses in the presence of focal infection were responsible for this complication in the right eye.

Fig. 4.—Clearing of the cornea after two years. Visual acuity with correction was 6/9, and the patient could read Jaeger's test type 1.

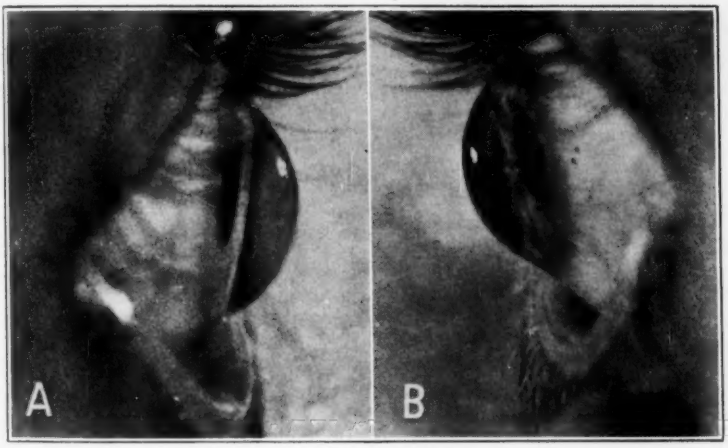

Fig. 5.—Side view of both eyes of the same patient two years after acute hydrops in the right eye. The right cornea (*A*) is thickened but normal in contour. Keratoconus persists in the left eye (*B*).

The patient has continued his work daily since the acute hydrops in his left eye, driving his car to and from his place of business and maintaining his usual reading and other close application of his eyes. All of his work has been done with the ordinary lens for his right eye (a + 12.00 sph. ⌒ + 5.00 cyl., ax. 120).

This patient was again examined by one of us (D. B. K.) on May 17, 1939, with the following findings:

The brows and lids were normal. The palpebral fissures measured 9 mm. in the right eye and 8 mm. in the left eye. There was no congestion of either eye. The cornea in each eye measured 12.5 mm. in diameter. The right cornea was clear except for a vertical linear opacity measuring 4 mm. by 1 mm. The left cornea had a 6 mm. disklike central opacity. With the slit lamp microscope, there was an opacity in the substance of the cornea. At the upper and lower poles of this opacity were three or four radiating lines formed by folds 1 mm. in length in Descemet's membrane. There were a few fine deeply placed vessels.

There was a dull, translucent, nebulous opacity of moderate density in the left eye. The optic section of the cornea showed a normal thickness at the periphery, increased thickness at the edge of the opacity and thinning at the center. There were a few deeply placed vessels. The anterior chambers were of average depth. The irides, pupils and lenses appeared normal. Tension was normal to touch. The exophthalmometer reading was the same for both eyes. The prospect is that there will be further clearing of the left cornea.

EXPERIMENTAL WORK

The flattening of the cornea and the change in the radius of curvature as indicated by the remarkable shift in refraction following this acute hydropic change caused one of us (D. B. K.) to raise the question whether or not this complication was a conservative one. Visual improvement has taken place in most of the cases reported despite a variance of methods of treatment. If rupture of the endothelium and Descemet's membrane resulted in a beneficial change in such eyes, one of us (R. O. R.) wondered whether it would not be advisable deliberately to induce such a hydropic change when the keratoconus is of high degree. Such eyes with extreme keratoconus may be lost because of corneal ulceration, perforation and panophthalmitis.

With this theory in mind, some experimental work was undertaken by one of us (R. O. R.) with a series of 24 rabbits, an effort being made to reproduce acute hydrops of the cornea by lacerating the endothelium and Descemet's membrane from the direction of the anterior chamber.

Leber in 1873 produced edema of the cornea by denudation of the endothelium, which was followed by opacification and swelling of the cornea. He and others (Panas, Rampoldi, Mellinger, Barri, Elschnig and Juler) demonstrated that this could be brought about not only by instrumentation but also by the introduction of chemicals into the anterior chamber, that the hydropic condition persisted until the endothelium regenerated over the injured area and that occasionally an opacity remained permanently.

Such a condition of acute corneal edema was reproduced without great difficulty, as revealed by the subsequent photographs, after a certain technical procedure was determined by trial of various methods.

A knife needle with a curved tip was inserted through the cornea near the limbus, the knife edge was turned forward and several incisions were made through the endothelium and Descemet's membrane in the central area, with immediate opacification of the cornea of various degrees. However, this method also traumatized the iris and lens in a number of cases, so that it was discarded for another technic, which has proved to be satisfactory.

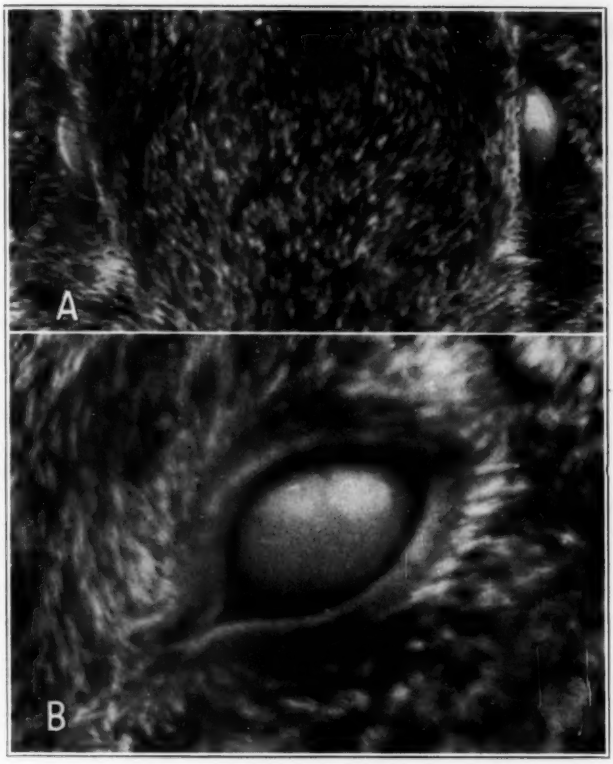

Fig. 6.—Front view (*A*) and side view (*B*) of experimental hydrops of the cornea induced in a rabbit twenty-four hours after posterior keratotomy.

General anesthesia was produced by the intraperitoneal injection of a solution made up as follows: sodium barbital 5 Gm., barbital 20 Gm., ethyl carbamate (urethane) 100 Gm. and distilled water 140 cc. One and five-tenths cubic centimeters of this solution per kilogram of rabbit weight afforded satisfactory and complete relaxation, which persisted from twelve to twenty-four hours.

A small keratome incision directed centrally was made in the cornea 4 mm. from the limbus. The chamber emptied practically entirely, and a curved cystotome or a foreign body spud with a sharp right-angled point was then inserted on the flat, the tip passed beyond the center of the cornea, the sharp edge turned forward

and the posterior corneal layers lacerated by drawing the instrument toward the point of entrance. More than one such laceration could be made, if desired, before withdrawal of the instrument. It was found that the Barkan goniotomy knife made an ideal instrument for this purpose. Immediate opacification took place in a small degree and increased in some cases to involvement of the entire cornea

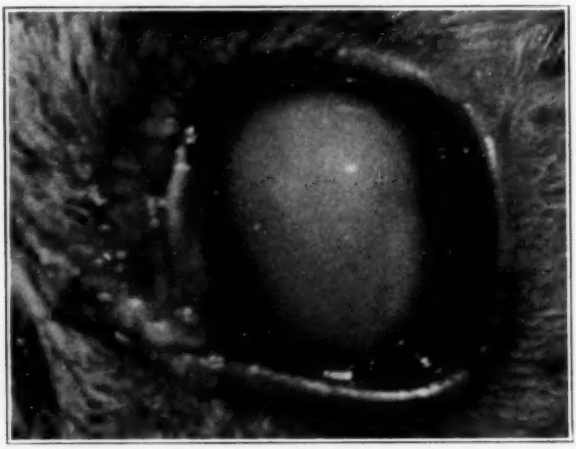

Fig. 7.—High power magnification of the left eye of the rabbit shown in figure 6. Increased density and ectasia of the cornea are seen in the superior portion.

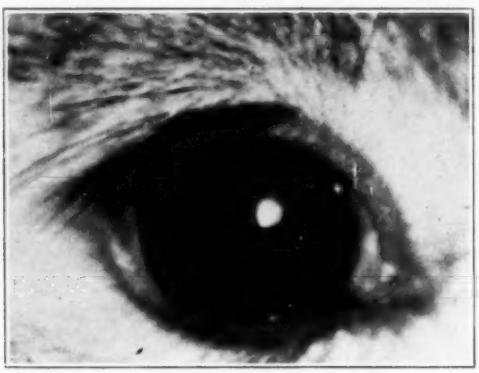

Fig. 8.—Clearing of the cornea one month after acute hydrops induced by posterior keratotomy.

within forty-eight hours. Clearing began after the height of aqueous invasion was reached and was complete within two weeks to two months. Deep striate opacities of the cornea remained permanently, however, and corresponded to those deep opacities which have persisted in cases of keratoconus complicated by acute hydrops.

Under the technic finally adopted, it was possible without complications to produce acute hydrops of the cornea in 28 consecutive eyes. It was surprising to find it possible to insert the instruments mentioned

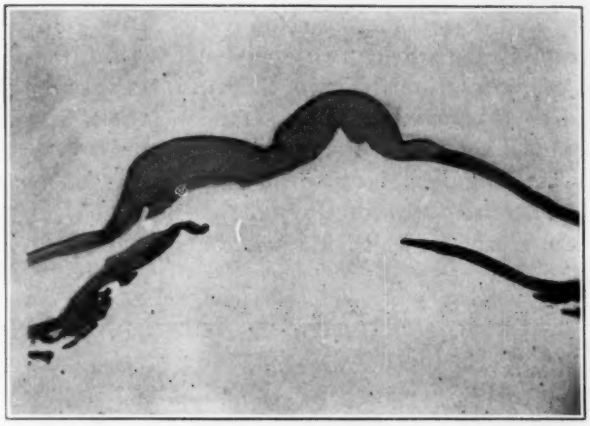

Fig. 9.—Acute hydrops of the cornea of a rabbit's eye twenty-four hours after posterior keratotomy. Descemet's membrane is retracted and curled on itself. A fibrinous exudate is present on the posterior surface of the cornea and the anterior surface of the iris.

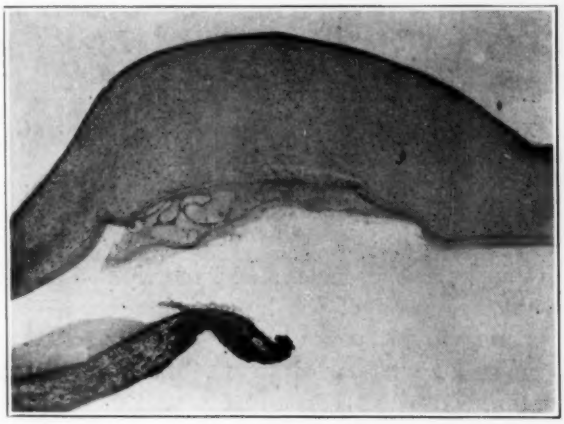

Fig. 10.—High power magnification of the section shown in figure 9. The corneal stroma is three times the normal thickness, with separation of the lamellas. There is marked retraction of Descemet's membrane.

into the anterior chamber without trauma to the lens, even though the chamber seemed to be optically empty. However, McMillan in his work on filling the anterior chamber with air after trephine operation had a similar experience.

EXPERIMENTAL PATHOLOGIC STUDY

The eyes of several rabbits were removed forty-eight hours after instrumentation, fixed in a 5 per cent solution of formaldehyde and sent to Dr. Georgiana Dvorak-Theobald, who prepared and examined them.

Sections demonstrated that an acute edema of the cornea had taken place, the cornea being swollen two to two and one-half times its normal thickness because of an imbibition of fluid in the stroma. The sections were cut so as to demonstrate the keratome incision as well as the lacerations in the endothelium and Descemet's membrane. The latter were somewhat magnified because the sections passed through them diagonally but demonstrated forcefully the elasticity of Descemet's membrane and the extent to which it retracts and rolls in on itself when it is cut or broken.

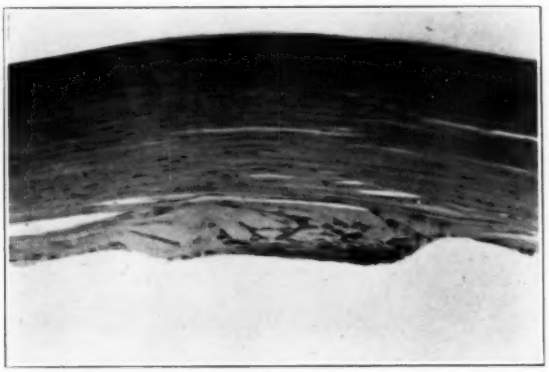

Fig. 11.—High power magnification of a section of the cornea from a rabbit's eye one month after posterior keratotomy and after clearing of the cornea had occurred. The endothelium has regenerated, and a mild fibrosis covers the area of trauma. The cornea has resumed its normal thickness.

Sections from similar eyes enucleated a month after instrumentation showed complete regression of the hydropic stage. The cornea had returned to its normal thickness after regeneration of an impervious endothelium, and only a mild fibrosis marked the area of trauma.

Sections from rabbit eyes enucleated twenty-four hours after the induction of acute hydrops of the cornea by posterior keratotomy were also examined by Dr. John S. McGavic, who found the following changes: The corneal stroma varied from normal thickness to an increase of three times over the normal in the central region. Here the lamellas were widely separated, and partially split, fine trabeculae connected the parts of the lamellas. Descemet's membrane had been ruptured in one to three places in different sections beneath the area of the hydropic stroma described. Descemet's membrane took a deeper

stain than usual and was about twice as thick as normal. The endothelium had a ragged vacuolated appearance. In some sections there was a fibrinous exudate in the anterior chamber just back of the injury to Descemet's membrane. The angle of the chamber and the iris were normal. There was a cellular exudate on the surface of the ciliary body.

The second eye showed the same stromal changes and injury to Descemet's membrane. However, Descemet's membrane was of normal thickness throughout. The endothelium showed the same change, and there was a similar fibrinous exudate behind the injured area. In this eye there was no cellular reaction on the surface of the ciliary body.

COMMENT

From the work reported it would seem that another surgical approach may be made in the treatment of keratoconus of a high degree when ulceration is impending. It is true that experimental keratoconus was not produced and reduced by this experiment. However, clearing of the cornea with actual flattening has occurred in the cases of acute hydrops complicating keratoconus which are recorded in the literature, and it seems reasonable to advocate the deliberate production of acute hydrops in some cases of advanced keratoconus. Certainly such a procedure need not be more difficult than the excision of an elliptic portion of the cornea nor produce more actual trauma to the eye than perforation of the cornea by actual cautery, and in the light of experimental results it seems more logical.

SUMMARY AND CONCLUSIONS

An additional case of acute hydrops of the cornea complicating keratoconus is added to the 8 cases of a similar condition previously reported in the medical literature.

In spite of the varied forms of treatment, in 9 of the 10 eyes in the cases reported to date the visual acuity has been maintained or actually improved. In the single eye in which blindness occurred the cornea had cleared, and the visual loss was due to some other cause than the complicating corneal edema.

Reduction of corneal ectasia and clearing of the corneal edema occurred uniformly in all cases regardless of the form of treatment used. Procedures such as tarsorraphy, sclerectomy, keratectomy and keratotomy were invoked to prevent a spontaneous rupture of the whole thickness of the cornea, a condition which has not as yet been recorded.

Experimental hydrops of the cornea has been produced in rabbits, and spontaneous clearing of the cornea took place after periods varying from two weeks to two months. Striate opacities corresponding to the

lacerations in Descemet's membrane persisted and were similar to those described following resolution of the complication in human eyes with keratoconus.

Posterior keratotomy is offered as a rational procedure in eyes affected by keratoconus in which visual acuity is reduced to a low degree or in which the protrusion of the cornea is of such a high degree that exposure of the cornea and its subsequent complications endanger the integrity of the eyeball.

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DISCUSSION

Dr. Harry S. Gradle, Chicago: The new term introduced by the authors, "acute hydrops of the cornea," is good and will undoubtedly find a permanent place in the nomenclature. Just how great is the rarity of this condition is difficult to say, for undoubtedly the majority of ophthalmologists of any great clinical experience have seen one or more cases but have failed to report them. I say this from personal experience, for I can add 2 cases to those here reported.

Thus, to supplement Drs. Kirby and Rychener's report, I wish to call attention to 3 eyes in 2 patients with keratoconus, keratectasia, rupture of Descemet's membrane and acute hydrops of the cornea. All 3 eyes were operated on, 1 by iridencleisis and 2 by iridectomy. The most striking feature of the postoperative course was the marked flattening of the keratoconus and the failure to progress that is naturally expected in persons of that age so afflicted. Undoubtedly, the acute hydrops resulted in the formation of connective tissue within the corneal stroma that prevented further bulging. Furthermore, the opacity in 1 of the eyes disappeared almost entirely, while the opacities in the other 2 eyes became permanent.

It is, of course, futile to speculate as to what might have happened had the condition been cared for by nonsurgical means, but judging from the report of the authors as to the course of the left eye in their patient, it would appear that much time and energy can be saved by immediate surgical intervention. Apparently iridectomy is simpler than multiple paracenteses, and iridencleisis appeared to be equally successful. The reason for any operative procedure is to effect an immediate reduction in intraocular tension, which is undoubtedly too high for that particular eye, thus producing the keratectasia and eventually the rupture of Descemet's membrane by the simple mechanical process of stretching to the breaking point. A priori, a simple iridectomy is to be preferred to an iris inclusion operation, because of the possible irritation of the subconjunctival iris by the contact glass that will eventually have to be fitted. However, practical experience has shown that this objection is more theoretic than real.

Dr. Trygve Gunderson, Boston: The reason the corneal stroma swells or takes on fluid when directly exposed to the aqueous is not at all clear. It cannot be merely a matter of fluid being pressed into the tissues from the anterior chamber, because the corneal parenchyma will swell in the absence of any pressure. For instance, an excised cornea will swell in only a fluid bath. Also the affinity of the corneal parenchyma for fluid seems even more remarkable, since this affinity is not directly attributable to osmosis. The cornea has been shown to take on fluid even when placed in a bath of a 10 per cent solution of sodium chloride, many times normal.

Leber's experiments also showed that the amount of swelling was practically the same if the immersion fluid were distilled water or a 2 per cent solution of sodium chloride. He contended that the swelling depends on the affinity of the fibrillae for fluid regardless of the osmotic pressure of the surrounding fluid. It is perfectly clear that the endothelium alone prevents this happening in the normal, living cornea. Descemet's membrane is doubtless of little importance.

In the study of experimental keratoconus, Plaut, Elschnig and Hess were able to produce marked swelling of the cornea by mechanical injury to the endothelium as well as by electric shocks, which did not disturb Descemet's membrane. It was found that it was unnecessary to disturb Descemet's membrane, even as von Hippel found it unnecessary to disturb it in his classic fluorescence experiment. Leber also found that excised Descemet's membrane offered no particular hindrance to the passage of fluids.

The fact that Descemet's membrane and its overlying endothelium ruptures in keratoconus suggests that there is an abnormality of this structure or that it is stretched in an abnormal manner. If the intraocular pressure in a normal eye is increased until the globe slowly ruptures, the first cracks do not appear on the posterior but on the anterior corneal surface. Ehlers has demonstrated this in the eyes of calves. One is also impressed by the elasticity of the normal Descemet's membrane when one sees a descemetocele such as occurs in a case of corneal ulceration with sufficient loss of corneal substance to allow Descemet's membrane to bulge forward.

Finally, I should like to draw attention to the similarity between Dr. Rychener's pathologic specimens and the pathologic specimens from

patients with so-called sclerosis of the cornea, described by von Hippel, Meller, Fuchs and Gilbert. Sclerosis of the cornea is purely a clinical concept. It is an edematous thickening of the cornea which occurs without previous ulceration. It has been reported as occurring in cases of trachomatous pannus, sclerosing keratitis or old glaucoma or in cases in which exudates have been layered on the posterior corneal surface for a long time.

DR. T. L. TERRY, Boston: In the past year a marked sudden increase in the height of the cones occurred in 2 patients with conical cornea under my care. Edema of the cornea was present and widespread, but it was not as extensive as that just reported and it was not the most important or the most obvious finding. One of these patients was treated with pressure applied by means of an elastic bandage, and a remarkable reduction in the amount of the cone was produced in twenty-four hours, so great that surgical intervention, which had been considered, was not carried out.

The condition of the second patient can best be illustrated by a lantern slide of molds of the cornea made (1) preparatory to having a contact glass manufactured, (2) after the sudden increase of the cone and (3) after treatment with pressure. For several days after the pressure was applied the cornea was moderately thin, although the conicity of the cornea was fully reduced. Eventually, after the pressure had been continued for a long time, a period of ten weeks, scar formation was sufficient so that the normal curve of the cornea was restored. Some six months has intervened, and this patient was able to resume her school work with practical vision, requiring no glasses for reading. The scar that resulted did not cover the entire pupillary area.

The term "acute hydrops of the cornea" is a good one, but I do not believe that it fits the condition in the particular type of cases I have mentioned, as there was much less edema of the cornea than in the case of Drs. Kirby and Rychener.

DR. RAMON CASTROVIEJO, New York: It is encouraging to see these patients with advanced keratoconus, as described by Drs. Rychener and Kirby, by Dr. Gradle and by Dr. Terry, improve after such minor surgical procedures, but even so there are some cases of keratoconus in which the condition is so advanced that it cannot be improved without surgical intervention.

Before, the surgical procedures that were used did not lead to good results. Nowadays, however, there is a method that offers the possibility of restoring good practical vision to these persons who before had little hope of ever regaining useful eyesight again. At the Institute of Ophthalmology I have performed corneal transplantations on 8 patients with advanced keratoconus. They have included persons with marked keratoconus and scars in the apexes of the corneas, persons whose condition could not be improved by wearing contact glasses and persons whose vision was much diminished and improvement by any means was impossible. They regained vision better than 20/58. Before the operation their vision was less than 10/200.

I mention this method only to offer encouragement to those who have been unable to obtain any improvement in cases of advanced keratoconus. Keratoconus is the most favorable type of eye for conical trans-

plantation. It is more favorable than the eye with interstitial keratitis or the eye with a central corneal scar following the inflammatory process.

Dr. Ralph O. Rychener, Memphis, Tenn.: The discussers have been most generous and informative. To the foregoing report have been added reports of 5 eyes with acute hydrops of the cornea complicating keratoconus and 4 different methods of treatment, which, added to those already described, makes 9 different forms of treatment utilized for this condition. Practically all of them have been perfectly successful.

Just what one needs to do in the future in these cases, is, of course, still a question that remains to be determined. Dr. Castroviejo's report is most encouraging. His operation seems by all means to be the method of choice for treatment of extreme keratoconus. However, it is not possible for all patients to have surgeons as expert in keratoplasty as Dr. Castroviejo, nor is material for corneal transplantation always available when needed. Sometimes such operations have to be done in some of the more outlying districts, like our own, and it may be that some simpler methods will suffice.

OCULAR SENSITIVITY TO NUPERCAINE

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Nupercaine, the hydrochloride of α-butyl-oxycinchoninic acid-γ-diethylethylenediamide, has been used as a local anesthetic for the past nine years. Its use in ophthalmology was described in 1933 by Dillon and Greer [1] and by Bochner.[2] The latter used a 0.5 per cent solution containing epinephrine hydrochloride for instillation, and for infiltration a freshly prepared solution (1 : 1,500) incorporating 10 drops of epinephrine hydrochloride for each 100 cc. The advantages claimed for nupercaine include prolonged anesthetic effect, relatively low toxicity and absence of effect on the corneal epithelium and on the intraocular pressure.

Toxic reactions have been reported after the employment of nupercaine in spinal anesthesia, and a few instances of dermatitis have been recorded from the use of an ointment containing nupercaine in the treatment of pruritus (Keyes and McLellan,[3] Fowlkes,[4] Fanburg,[5] Hailey and Hailey [6] and Cameron [7]).

Dr. Charles H. May and I have been using nupercaine for over five years as a topical anesthetic for the conjunctiva and cornea, preparing a 1 : 500 solution in physiologic solution of sodium chloride. The drug has proved satisfactory for tonometry, for removal of corneal and conjunctival foreign bodies and for the treatment of conjunctivitis and

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From the Department of Ophthalmology, College of Physicians and Surgeons, Columbia University, and the Institute of Ophthalmology of the Presbyterian Hospital.

1. Dillon, E. E., and Greer, C.: Use of Nupercaine in Ophthalmology, Arch. Ophth. **10**:674-677 (Nov.) 1933.

2. Bochner, M. K.: Use of Nupercaine in Ophthalmology, Arch. Ophth. **10**: 763-767 (Dec.) 1933.

3. Keyes, E. L., and McLellan, A. M.: Further Experiences with Nupercaine, J. A. M. A. **96**:2085-2091 (June 20) 1931.

4. Fowlkes, R. W.: Dermatitis Due to Nupercaine, J. A. M. A. **100**:1171 (April 15) 1933.

5. Fanburg, S. J.: Dermatitis Due to Nupercaine, J. A. M. A. **101**:30-31 (July 1) 1933.

6. Hailey, Howard, and Hailey, Hugh: Dermatitis Caused by Nupercaine, Arch. Dermat. & Syph. **36**:1084-1085 (Nov.) 1937.

7. Cameron, O. J.: Skin Eruptions Due to Nupercaine and Pantocain, Nebraska M. J. **22**:229-230 (June) 1937.

corneal ulcers. We have encountered only one example of local ocular sensitivity to nupercaine in over 10,000 instillations. I have been unable to find a record of toxic ocular reaction in the literature. The extreme rarity of this condition prompts the presentation of the following case, which is reported with Dr. May's permission.

REPORT OF A CASE

Mrs. M. A. W., a 63 year old white woman, was first seen by Dr. May in 1934. She had complaints referable to hyperopia and a chronic conjunctivitis.

Fig. 1.—Edema of the lids and conjunctiva due to sensitivity to nupercaine.

Fig. 2.—Side view of patient with sensitivity to nupercaine.

Glasses were prescribed, and the conjunctiva of her everted lids was lightly touched with the copper sulfate stick after local anesthesia with three instillations of a solution of nupercaine (1:500). Her symptoms disappeared for three years.

She returned in 1937 with complaints related to her conjunctivitis. Treatment with the copper sulfate stick, preceded by instillations of nupercaine, was followed by edema and itching of the lids for several days. This was relieved by the instillation of 2 drops of a solution of epinephrine hydrochloride (1:1,000) into each conjunctival sac. An allergic reaction was suspected.

I saw the patient in August 1939, during the absence of Dr. May. She was suffering from a subacute catarrhal conjunctivitis, which responded well to the application of 1 per cent silver nitrate after anesthesia with nupercaine. There was slight edema of the lids for four days thereafter. The patient stated that she had mild asthma and was sensitive to wool, fur and sunlight. One week after the treatment with silver nitrate, I anesthetized the conjunctiva with nupercaine and applied the copper sulfate stick lightly, following this with repeated irrigations and the instillation of epinephrine hydrochloride (1:1,000). In spite of this there was a moderate allergic reaction for three days. After another week I treated the patient's conjunctiva lightly with the copper sulfate stick without preliminary anesthesia of the conjunctival sac. There was prompt disappearance of all symptoms.

I asked the patient for her permission to allow me to instil nupercaine into her conjunctival sacs as a final test of her sensitivity to this drug. She returned to have this done on Nov. 2, 1939. The accompanying photographs (taken by Mr. A. Marfaing at the Institute of Ophthalmology of the Presbyterian Hospital) show the appearance of her eyes two days later.

The conjunctiva of the patient has been recently treated after topical anesthetization with butyn, without a subsequent allergic reaction.

DISCUSSION

DR. DAVID WEXLER: I have used nupercaine in solution with epinephrine hydrochloride many thousands of times and have never encountered any instance of sensitivity. Perhaps the epinephrine prevents allergic manifestations.

DR. JAMES W. SMITH: It is interesting that Dr. Perera used butyn on his patient after a reaction from nupercaine. Of the local anesthetics used in ophthalmology, butyn probably produces unfavorable reactions most frequently. Even pontocaine hydrochloride, which is gaining in popular use, will occasionally produce conjunctival and cutaneous reactions in susceptible patients.

DR. CHARLES PERERA: In regard to the use of epinephrine hydrochloride with nupercaine, I believe that one of these days, whether epinephrine is used or not, another case of sensitivity will appear. I think the use of epinephrine in combination with nupercaine may give less opportunity for sensitivity to develop, and it is possible that if we had started with the combination the patient would not have reacted to nupercaine and we would not have had this report.

BENIGN MELANOMA OF THE CILIARY BODY

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In none of the 9 reported cases of benign melanoma of the ciliary body found in the literature was the growth suspected before its accidental finding on section. There was justification for using the term melanoma for the growth in 4 of the cases,[1] but in the other 5 the tissue showed either a diffuse arrangement of the pigment-bearing cells or mere sheaths of a pigment layer. In these 4 cases the melanoma occurred in the pars plana of the ciliary body, which point is of interest in that it allows for conjecture as to the time of origin.

Embryologically, even by the fifth month the pars plana is hardly visible. By the seventh month the ora serrata lies on a level with the middle of the ciliary muscle; by the eighth month it lies adjacent to, and at birth it is behind, the ciliary body. If one were to hold to the congenital occurrence of melanomas, although admitting they may occur in adult life, their first appearance must be rather late in gestation.

Alexander, after presenting a complete monograph on this subject, ended with the thought that "one can reasonably conclude that some relationship certainly exists between chronic inflammation and the formation of melanomas in the ciliary body." The total absence of any factor of this nature in the case here presented would seem to speak adversely concerning this assumption. In 5 of the other reported cases there were other accompanying pathologic changes, and in 3 there was no other abnormality; the remaining case was not reported in full enough detail to permit a conclusion one way or the other.

REPORT OF A CASE

C. L., a housewife aged 63, was admitted to the hospital on Nov. 4, 1932, with a diagnosis of general arteriosclerosis, coronary sclerosis, gangrene of the right foot, diabetes and embolism of the right popliteal artery.

Laboratory tests revealed: hemoglobin, 94 per cent; white blood cells, 14,600; polymorphonuclear leukocytes, 80 per cent; lymphocytes, 16 per cent; basophils, 2 per cent, and monocytes, 1 per cent. The sugar content was 110 mg. per hundred

1. Fuchs, E.: Arch. f. Ophth. **94**:43, 1917. Foster Moore, R.: Roy. London Ophth. Hosp. Rep. **19**:411, 1914. Schappert-Kimmyser, J.: Arch. f. Augenh. **100-101**:46, 1929. Heine, L.: Arch. f. Ophth. **3**:33, 1923. Sattler, H.: Die bösartigen Geschwülste des Auges, Leipzig, S. Hirzel, 1926. Alexander, B.: Pathology of Melanosis and of Benign Melanomas of the Ciliary Body, Arch. Ophth. **7**:521 (April) 1932.

cubic centimeters (after three days in the hospital). Two days previously the sugar content of the urine was 0.5 per cent. The Wassermann reaction was negative.

Both eyes were normal externally. The pupils were equal. The light reaction, direct and consensual and the accommodation reaction were normal. The conjunctiva and the sclera were clear. There was no exophthalmos. The muscles, media, tension and fundi were normal except for slight narrowing of the arteries.

The gangrene was treated conservatively. By the patient's sixth day in the hospital progressive mental deterioration was present. This rapidly developed into acute psychosis. On the tenth day the total white cell count was 23,000 with 93 per cent polymorphonuclears. On the fourteenth day after admission the patient died.

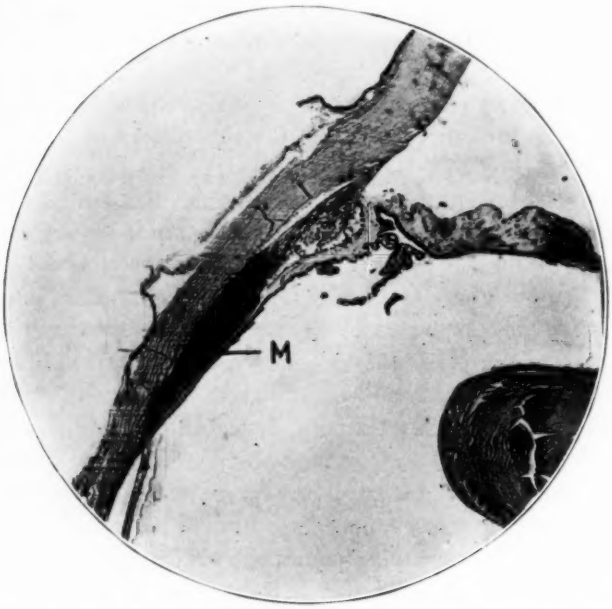

Fig. 1.—Melanoma (*M*) of the pars plana, as seen with a loupe.

Necropsy revealed moderate general arteriosclerosis, coronary sclerosis without narrowing, slight fibrosis of the myocardium, moderate dilatation of the right and left ventricles, fibrosis of the liver, pulmonary emphysema, atrophy and old infarct of the spleen, cholesterosis of the gallbladder, lipomatosis of the pancreas and endometrial polyp. The skin did not show any pigment disturbances or nevi.

The globes were fixed in both Müller's solution and diluted solution of formaldehyde U. S. P. (1:5). They were embedded in paraffin and pyroxylin.

Microscopic examination of the ocular structure showed the right eye to be normal. In the parenchyma of the pars plana of the left eye on the nasal side lay a blackish brown pigmented mass measuring 1.8 mm. in length and 9 mm. in width (fig. 1). The pole toward the ora serrata was more pointed than the other, which was more rounded and fairly definitely defined, although not being surrounded by a capsule; many pigment cells of the same nature as that of the mass extended into the neighboring stroma, as suggested in figure 2. To make

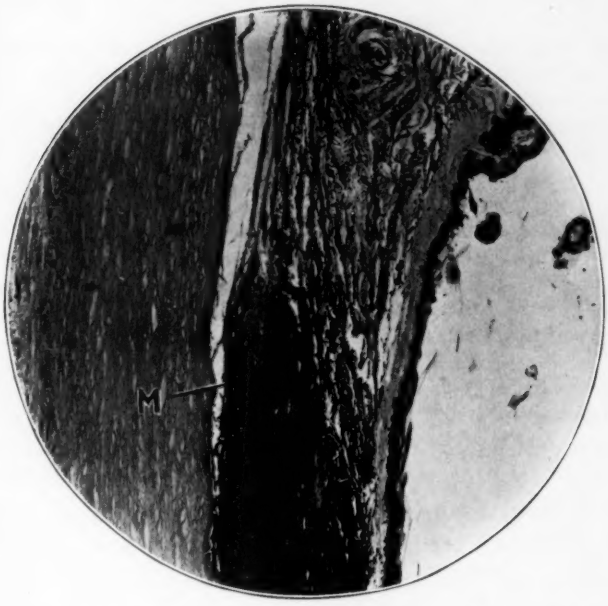

Fig. 2.—Low power magnification of the melanoma (*M*).

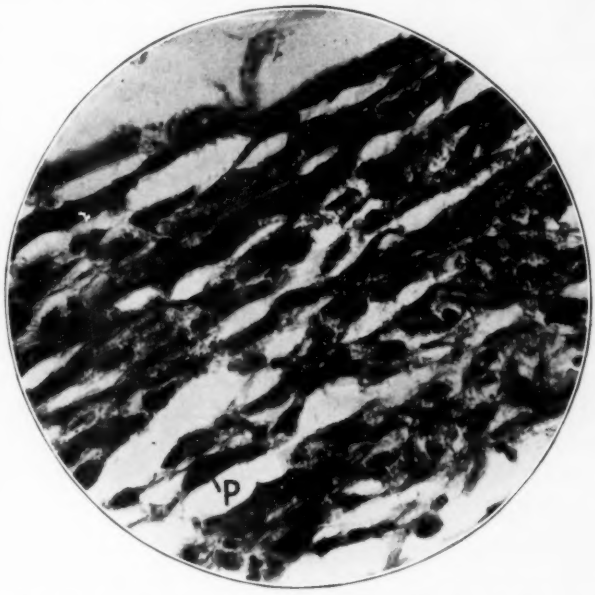

Fig. 3.—Spindle-shaped cell (*P*) showing the nucleus being pushed to one side of the cell.

histologic study possible, depigmentation by means of a weak solution of potassium permanganate and oxalic acid was used. Sections were then stained with hematoxylin and eosin, Mallory's connective tissue stain, Weigert's iron-hematoxylin and Van Gieson's stain.

The Mallory connective tissue stain showed plainly the numerous capillaries scattered throughout the tumor, the blood cells staining red. The elastic tissue stain brought out the compression of the fibers, as was so excellently demonstrated by Alexander. With the Van Gieson stain it was easy to differentiate the muscle tissue from the connective tissue, both of which traversed the tumor, although the muscle tissue was more compact next to the sclera.

The cells themselves were mostly ovoid, tending toward spindle shape (fig. 3). There was much cytoplasm, and here and there the nuclei pushed to the cell wall, as from the overcrowding of pigment. In the better depigmented portions suggestions of nuclear structure could be made out, in contrast to the definitely demarcated muscle nuclei, in which even the nucleolar structure stood out. The pigment was practically all intracellular and composed of roundish granules of varied degree of intensity. It was negative for iron by the Turnbull stain.

COMMENT

The final word as to whether all types of nevi can undergo malignant changes has not been written and probably will not be until more accurate differentiation of the types of nevi can be made either by histologic, embryologic or chemical means or by a combination of such approaches. In support of the contention that they can take malignant changes are arrayed Foster Moore, Wagner and Wellbrock [2] and Shumway and Heine. King,[3] concluded: "It may be assumed that the changes from innocency to malignancy is on occasion certain in the melanomata of the skin and iris and highly probable in those of the ciliary body and choroid." Schreck's description of a sarcomatous degenerating nevus of the iris is interesting in this connection.

Of equal importance is the determination of the origin of melanomas in general. Reviewing the various theories, one finds some authors who support the epithelial cell origin, others the mesoblastic theory and finally the majority, who today, like Ewing,[4] state "there is no longer any room for debate as to the nervous origin of these tumors."

This theory dates from 1882 when von Recklinghausen pointed out their frequent association with neurofibromas of the skin. Soldan in 1899 confirmed this fact and made the observation that nerve fibers could be traced among groups of melanoma cells. Masson [5] developed the idea in 1926. The cutaneous nerve ends in two ways—on the one hand, the neurilemma, or the nucleated sheath of Schwann of the medul-

2. Wagener, H. B., and Wellbrock, L. A.: Tr. Am. Ophth. Soc. **28**:100, 1930.

3. King, E. F.: Tr. Ophth. Soc. U. Kingdom (pt. 1) **57**:97, 1937.

4. Ewing, J.: Neoplastic Diseases, Philadelphia, W. B. Saunders Company, 1928; Brit. M. J. **2**:852, 1930.

5. Masson, P.: Ann. d'anat. path. **3**:417 and 657, 1926.

lated nerve, becomes differentiated into a capsule, the Meissner corpuscle, situated in the derma and, on the other hand, nonmedullated nerve fibrils enter the basal layers of the epithelium to ramify around two specialized cells found there, meniscus-shaped cells of Merkel-Ranvier and pigment-bearing chromatophores. Masson regarded the melanoma as a tumor formation of the specialized end apparatus, both among the epithelial cells and in the derma beneath them. He visualized the neural cell as capable of differentiating to form the chromatophore. Dawson's [6] suggestion that one draw an analogy between epithelium and subepithelial mesoblastic tissues of the skin with the neuroepithelium of the retina and uveal tract helps to carry over the description to the immediate field. In this connection the case reported by Goldstein and Wexler [7] of melanosis uveae and melanoma of the iris in a patient with neurofibromatosis is of the greatest importance in bearing out this contention.

The extent to which neurofibromatosis may involve the ciliary body is excellently demonstrated in a case reported by Wheeler.[8] "The ciliary body and choroid are enormously thickened by the acquisition of tumor tissue which replaces all of the normal elements of the ciliary body, except some of its muscle bundles. The tumor is composed of nonmedullated nerve fibers and many foci of ganglion cells. There are also large areas of spindle-shaped cells, the protoplasm of which contains pigment."

To Dvorak-Theobald [9] goes the credit of applying these data to the choroidal sarcoma and demonstrating the probable neurogenic origin of these growths. Application of the same methods to melanomas of the ciliary body should result in like findings.

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6. Dawson, J. W.: Edinburgh M. J. **32**:501, 1925.

7. Goldstein, I., and Wexler, D.: Melanosis Uveae and Melanoma of the Iris in Neurofibromatosis (Recklinghausen), Arch. Ophth. **3**:259 (March) 1930.

8. Wheeler, J. M.: Am. J. Ophth. **20**:368, 1937.

9. Theobald, G. D.: Neurogenic Origin of Choroidal Sarcoma, Arch. Ophth. **18**:971 (Dec.) 1937.

VACCINAL DISCIFORM KERATITIS FOLLOWING ACCIDENTAL INOCULATION OF THE EYELID

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NEW YORK

Accidental vaccinal inoculation of the eyelids is uncommon but not infrequent, judging from the number of reports in scientific publications. Involvement of the cornea is rare and is usually secondary to infection of the lids and conjunctiva. Only a few examples of a primary corneal lesion due to the vaccinia virus have been recorded, and these have occurred almost exclusively in physicians, nurses or laboratory workers whose eyes were injured or infected during the process of vaccinating patients or of preparing vaccine lymph.

The corneal lesions which result from vaccinal infection may be classified as slight subepithelial infiltrations, superficial vesicles, disciform keratitis and ulcers and pustules which may advance to perforation and its sequelae. The superficial types of corneal involvement usually heal with little or no residual opacification; the deeper forms leave scars of varying density, often with considerable impairment of vision in the affected eye.

Fuchs [1] in 1901 called the attention of ophthalmologists to the clinical entity which he called disciform keratitis. Schirmer,[2] who first reported a case of postvaccinal disciform keratitis in 1891, reviewed this subject in 1904, describing the 6 cases previously reported and adding a seventh. He gave as characteristic features of this condition: (1) central or paracentral, parenchymatous, gray disciform involvement of the cornea, with overlying epithelial stippling or defect, (2) a deep, circular, grayish line, consisting of a single ring or two concentric lines, (3) involvement of Descemet's membrane, (4) a slight uveal reaction, (5) a clear peripheral cornea and (6) a course of long duration, lasting at least six weeks and leaving permanent corneal opacities. According to this

Presented before the Section of Ophthalmology of the New York Academy of Medicine, Dec. 18, 1939.

From the Department of Ophthalmology, College of Physicians and Surgeons, Columbia University, and the Institute of Ophthalmology of the Presbyterian Hospital.

1. Fuchs, E.: Ueber ringförmige und scheibenförmige Keratitis (Keratitis annularis et disciformis), Klin. Monatsbl. f. Augenh. **39**:513-523, 1901.

2. Schirmer, O.: Ueber Keratitis disciformis und Keratitis postvaccinolosa, Arch. f. Ophth. **59**:133-145, 1904.

author, the disease begins in the corneal epithelium, with subsequent changes in the underlying stroma.

More recent writers who have described cases of postvaccinal disciform keratitis include Morax,[3] Smith,[4] Grüter,[5] Sinaiko[6] and Portoghese.[7]

REPORT OF A CASE

L. E., a 32 year old married white man, came to my office on June 28, 1939, giving the history of a "stye" of his right upper eyelid for six days and marked swelling of the right eyelids and right side of the face for two days. The lesion on the lid had been "opened" by a surgeon on the preceding day. Treatment had consisted of lavage of the eye with a solution of boric acid and the application of hot compresses.

Examination revealed extensive edema of the lids of the right eye and of the right side of the face, with nontender enlargement of the right preauricular lymph

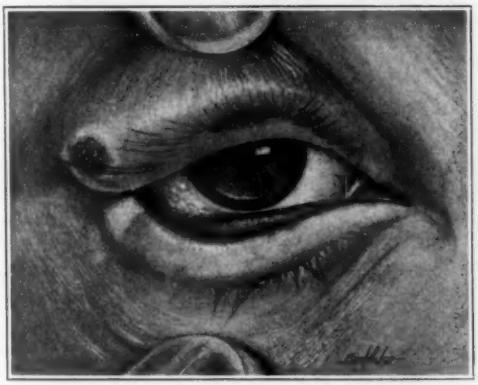

Fig. 1.—Accidental vaccinia of the eyelid. The appearance of the lesion eleven days after infection and five days after the onset of symptoms. (Drawing by Mr. Bethke.)

node. The outer portion of the right upper lid contained a rounded indurated elevation surmounted by a superficial grayish area of ulceration. This site was traversed by a small horizontal incision containing some mucopurulent secretion. An area of the right lower lid which was in contact with the lesion of the upper lid showed a grayish superficial change in the skin. The conjunctiva of the right eye was edematous and congested, with a slight mucoid discharge. The right cornea was clear. Figure 1 shows the appearance of the right eye. The left eye was normal.

3. Morax, V.: Vaccine oculaire et inoculation vaccinale de la cornée humaine, Ann. d'ocul. **152**:345-351, 1915.

4. Smith, C. L.: Disciform Keratitis Following Smallpox, Am. J. Ophth. **5**: 32-34, 1920.

5. Grüter, W.: Das Bild der Vakzinekeratitis beim Menschen und Kaninchen, Ber. ü. d. Versamml. d. deutsch. ophth. Gesellsch. **46**:414-416, 1927.

6. Sinaiko, A.: Keratitis Postvaccinolosa, Arch. Ophth. **5**:91-92 (Jan.) 1931.

7. Portoghese, G.: Localizzazioni oculari di vaccinosi accidentali, Ann. di ottal. e clin. ocul. **62**:308-320, 1934.

The incision was cleaned, a wet dressing was applied, and the patient was sent to the Institute of Ophthalmology of the Columbia-Presbyterian Medical Center for cultures of material from the ulcer and conjunctiva, a Kline test of the blood and photographs.

I made the diagnosis of granuloma and referred the patient to Dr. P. Thygeson for his opinion. He obtained a history from the patient which confirmed his suspicions that the condition was vaccinia of the eyelid. On June 17 the patient, who had been successfully vaccinated against smallpox in his childhood, had changed the dressing which covered the ruptured pustule at the site of a recent vaccination for smallpox on the arm of his 18 month old child. There was no history of venereal disease, and the Kline test of the blood was negative. The cultures of material from the coated ulcer of the lid and from the conjunctiva showed no growth

Fig. 2.—Vaccinal disciform keratitis. The appearance of the corneal lesion twenty-two days after the onset of symptoms of involvement of the eyelid and nine days after the onset of corneal signs and symptoms. The annular line of opacification lies in the deep layers of the cornea. The white dots are on the posterior layer of the cornea. The central opacities are subepithelial and deep. The folds in Descemet's membrane, which were present two days before, have disappeared. (Drawing by Mr. Bethke.)

of pathogenic organisms. Inoculation of a rabbit's cornea with material from the surface of the ulcer of the lid did not produce any positive reaction.

A lesion similar to that on the upper lid rapidly developed on the right lower lid. Daily application of a loose dressing of an ointment containing mercury bichloride in a concentration of 1 : 3,000 resulted in subsidence of the edema of the lids and conjunctiva.

On July 5, thirteen days after the onset of symptoms, the patient complained of photophobia and attacks of pain in his right eye. Examination at that time

revealed a superficial corneal ulcer in the outer pupillary area of the right eye. A 2 per cent solution of atropine sulfate was instilled and an occlusive dressing applied daily. On July 10, eighteen days after the onset of symptoms, there was no staining of the cornea with fluorescein.

On the nineteenth day the site of the ulcer of the cornea presented a rounded subepithelial haze, with a grayish white ring in the deeper layers of the cornea peripheral to this area. On the twentieth day there were added a central deep opacity beneath the superficial granular haze, refractile deposits on the posterior layer of the cornea and folds in Descemet's membrane. The deposits and folds were seen only within the region bounded by the deep annular opacity. Slit lamp examination did not reveal any floaters in the anterior chamber. On the twenty-second day the folds in Descemet's membrane had disappeared and there was a slight elevation of the opaque area in the center of the corneal lesion. Figure 2 shows the cornea on the twenty-second day.

The use of dressings was discontinued, and the application of hot compresses was instituted. The deep annular opacity gradually faded, and the central loss of transparency diminished. Vision of the involved right eye was normal by the fifty-fifth day. The corneal opacity continued to clear. A faint scar is all that remains to mark the site of the original corneal lesion.

COMMENT

The diagnosis of accidental vaccinal infection depends largely on the history of contact with a pustule from a recent vaccination for smallpox or with the vaccinia lymph used for such vaccination as well as on the typical appearance of the coated ulcer of the eyelid or characteristic pustular lesions. The finding of Guarnieri bodies in direct smears or after inoculation of the material on the cornea of a rabbit offers confirmatory evidence.

The annular shape of the deep opacity and the restriction of the posterior corneal changes to this area suggest a toxic effect on the stroma and endothelium of the cornea within a certain range of the epithelial infection with the virus. The folds in Descemet's membrane, which are also often seen immediately beneath dendritic and other types of superficial corneal ulcers, probably depend on injury to the underlying corneal endothelium with alteration in its permeability and the entrance of fluid from the aqueous into the posterior layer of the cornea.

Treatment of vaccinal disciform keratitis consists in atropinization and the use of hot compresses. Instillations of ethylmorphine hydrochloride and diathermy have also been used. The lesions on the lid respond to the use of mild antiseptic washes.

Parents and others who are caring for recently vaccinated children should be cautioned regarding the possibility of contact infection.

SUMMARY

The literature on vaccinal disciform keratitis is reviewed, and the characteristic features of this rare condition are outlined. A typical

case is presented in which a young man was accidentally infected from the recent vaccination pustule of his child. It is suggested that the changes in the deep layers of the cornea depend on injury to the corneal endothelium and the entrance of aqueous as well as to direct toxic action of the infective virus.

DISCUSSION

DR. PHILLIPS THYGESON: I should like to point out that there can be multiple clinical pictures of this condition. I have seen 2 other cases. In the first only the cornea was involved. The patient was an infant in whom accidental infection produced only a corneal pustule without involvement of the margins of the lids. In the second case there were multiple pustules on the margins of the lids without corneal involvement.

DR. DANIEL M. ROLLETT: I should like to ask whether or not the eye was treated after the lids became inflamed and before the corneal ulcer appeared.

DR. ARTHUR BEDELL: In this connection it is advisable to remember that a patient may convey the virus from his own arm to his own eye. I saw a 5 year old child who had scratched his recently vaccinated left arm and then rubbed his right eyelid, with the result that he had multiple lesions of both lids. A severe reaction occurred without corneal involvement.

DR. CHARLES A. PERERA: In answer to the question concerning the interval between the beginning of the ulcer of the lid and the development of the corneal ulcer, I saw the patient on the sixth day after the onset of his ocular symptoms. Between the sixth and the thirteenth day, when a superficial ulceration of the cornea developed, the patient was seen daily. The lesions on the lid had increased to involve the lower lid just as extensively as the upper one and had then started to diminish. The corneal lesion appeared before the ulcers on the lids had healed. Treatment continued until the corneal involvement was reduced to a small area of opacity.

RHINOSPORIDIOSIS OF THE CONJUNCTIVA

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AND
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Rhinosporidiosis of the nose has been reported 8 times in the United States, and it was not until the case of Anderson and Byrnes and another of Griffey that conjunctival rhinosporidiosis was recognized in this country.

To summarize the history and characteristics of the disease, the following statements are briefly given:

The disease is a local fungus infection of the mucous membrane. The fungus was classified by Ashworth in 1923 among the Phycomycetes, suborder Chytridinae. He named it Rhinosporidium seeberi and found it identical with the organism described by O'Kinealy.

The mode of infection is not known. Wright suggested, because of its predilection to the conjunctiva and the nares, that it might be air or water borne. This has not been proved. So far, experimental evidence has been negative. No one has been able to grow the fungus on artificial mediums except Ashworth, and his isolation of it was doubtful. Animal experimentation has not been helpful. The organism could not be transferred to monkeys, rabbits, guinea pigs, rats or mice.

The geographic distribution is interesting. The first cases were studied by Seeber in Argentina, but most of the cases have been reported from Western India and Ceylon. Additional cases have been reported from the Union of South Africa, Uruguay, Philippine Islands and the United States, and 1 case of conjunctival involvement has been reported from Europe.

The disease is mostly confined to the male sex, although Allen reported 5 cases from India in which 4 of the patients were females. In all the cases in the United States the patients have been males. The disease also occurs spontaneously in animals. It has been reported in horses, mules and cattle. It is interesting to note that all these animals were males except one.

The most common site of infection is the anterior nares. It is also found in the larynx, uvula, aural meatus, penis, conjunctiva and the lacrimal sac. It is believed by most investigators that it can affect any

This case was presented before the Section on Ophthalmology of the College of Physicians of Philadelphia on Oct. 26, 1939, at which time it was thought to be the first case of conjunctival rhinosporidiosis reported in the United States.

mucous membrane. There have been several cases of infection of the conjunctiva reported. Kilpatrick reported a case in which the lacrimal sac was involved and recovery occurred with excision of the sac. Kaye reported an interesting case in which two polypoid lesions due to Rhinosporidium had been removed from the upper lid, and later there had been a recurrence at the limbus. This was removed without recurrence.

Clinically, the condition consists of a polypoid growth of the conjunctiva. It is often highly vascular and bleeds easily. On its surface can

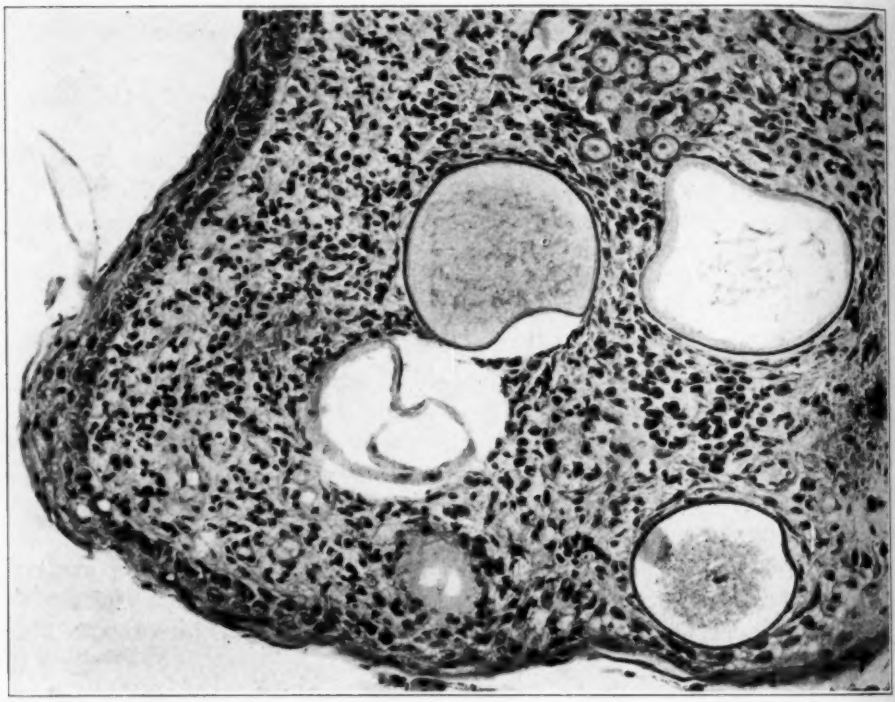

Fig. 1.—Section of conjunctiva showing small organisms in the trophic stage as well as developing sporangia; × 120.

be seen little white areas, which those who are familiar with the disease are able to recognize as the mature sporangia.

The treatment has not been standardized. In the cases in which the conjunctiva is affected, excision of the growth with the base has been proved successful. In involvement of the lacrimal sac, excision of the sac is necessary. In those multiple cases of involvement of the nose, in addition to excision Wright used neostibosan (a pentavalent antimony compound) intravenously, with the object of killing the parasite.

REPORT OF A CASE

R. M., a youth of 17 years, reported to the ophthalmic clinic of Dr. J. S. Shipman at the Cooper Hospital in Camden, N. J., on May 19, 1939. He complained of a growth beneath the right upper lid, which had been present since March 1939. Dr. Louis Ruttenberg examined the patient and, on eversion of the upper lid, found a quite vascular papillomatous growth springing from the palpebral conjunctiva at the upper border of the tarsal plate. The lesion measured 2 by 4 mm. Dr. Ruttenberg realized that he was looking at something unusual and asked one of us to examine it. It was decided to send the growth for pathologic examination, as it was thought that it consisted of some granulomatous tissue,

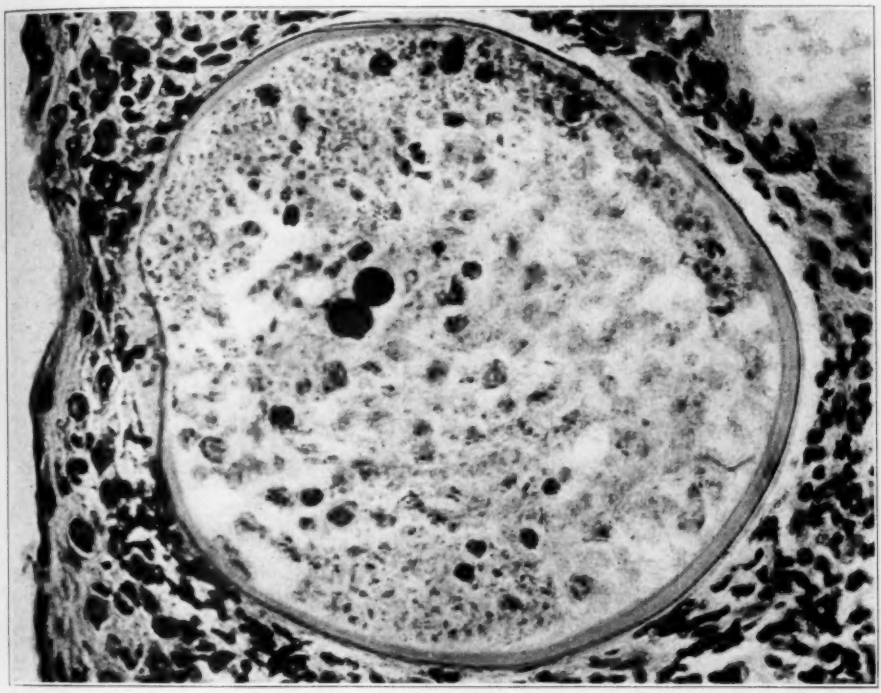

Fig. 2.—Sporangium almost fully developed containing spores; × 600. The cellulose membrane is well seen.

probably from a ruptured chalazion. The growth was removed at its base with a slight amount of bleeding.

Histologic section revealed a parasitic infiltration of the conjunctiva, and the diagnosis of rhinosporidiosis was suggested by Dr. Herbert L. Ratcliffe, of Philadelphia. Reference to case reports in the literature confirmed the diagnosis.

The patient was requested to return to the clinic, and a more thorough history was elicited. He was born in Philadelphia on Jan. 23, 1922 and moved to Pennsauken, N. J., a suburb of Camden, where he has lived ever since. He had traveled out of the state only a few times. He took a trip to the state of New York in 1938, and the farthest south he had ever been was Maryland. He has never associated with any one from India and has never lived on a farm. He

was a member of the Merchantville, N. J., swimming team, and while a member of this team he first noticed the mass beneath his lid. No other members of the family have had a similar condition.

Examination by Dr. Clark, of the otolaryngologic clinic of the Cooper Hospital, did not demonstrate any lesions of the nose or throat. The last examination, on Sept. 22, 1939, revealed no recurrences of the conjunctival growth.

The histologic picture presented by rhinosporidiosis has been adequately described by most of the authors of case reports in the literature. Ashworth's monograph in 1923 contains the classic description of the growth and development of the organism. In brief, however, the findings are as follows:

There is a local inflammatory reaction which is not severe and is composed of infiltration of lymphocytes and plasma cells with occasional small hemorrhages. Some authors describe foreign body giant cells which appear with degenerating sporangia but which were not present in our sections.

The chief interest lies in the organism itself, which occurs free in the connective tissue and at first measures about 6 microns in diameter. This is called the trophic stage. It has a dark cellular membrane, the chitinoid envelop and a nucleus with a karyosome. The cell enlarges to 50 to 60 microns when the nucleus begins mitotic division. At about 100 microns the parasite begins to develop a layer of cellulose-like material on the inner surface of the envelop. At about 140 microns the parasite contains about 16,000 nuclei; as they have now developed into definite cell entities they are in reality young spores, and the whole parasite is termed a sporangium. About two thirds of the spores develop and on enlarging acquire refractile spherules in the cytoplasm. The sporangium becomes 250 microns or more in size, and at this point the wall is stretched thin until finally the envelop is broken and the young spores are discharged. These have already reached the trophic stage and are ready to develop into mature sporangia in turn.

In our sections parasites of 20 microns or less are seen, and the largest sporangium measures about 180 to 200 microns. In the latter, small spores with refractile spherules are seen. The wide cellulose shell is striking. In the smaller organisms the chitinoid envelop is more easily demonstrated.

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DISCUSSION

DR. WILLIAM T. READ JR.: The pathologic picture of rhinosporidiosis is one of chronic inflammation, the organisms being found in the inflammatory tissue. The picture in this case resembles that in all those previously reported. The smallest organism in our sections measured 20 microns; the largest, 250 microns. The latter contained numerous spores and a well developed cellulose wall beneath the chitinoid envelop. One organism was extremely near the surface epithelium and suggested that spores might discharge from the conjunctival surface. The large organism with spores is called a sporangium. The entire lesion measured 2 to 3 mm. in diameter.

ANOMALOUS RETINAL VEIN CROSSING THE MACULA

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The region of the macula, and especially the fovea, is so consistently free of retinal blood vessels that any large blood vessel in that region is looked on as a definite anomaly. Numerous anatomists [1] who have studied the circulation of this region have shown that it is supplied and drained almost entirely through capillaries. In fact, injected specimens of the retina have demonstrated that the fovea centralis itself is devoid even of capillaries. The choriocapillaris, on the other hand, is thicker in this area than elsewhere. Because the number of cases in which retinal blood vessels of large caliber cross the macula are so few, they deserve to be mentioned when they do occur.

The earliest case that I could find was reported in 1868 by Mauthner.[2] He mentioned only 1 case in which he saw a vein of a large caliber unaccompanied by an artery going directly through the macula slightly above the fovea. A similar case was reported by Randall [3] in 1887. The report of Randall's case was accompanied by a drawing of the anomaly, which is so similar to the anomaly in the case that I am going to report that I should like to describe it more fully. The patient, a girl of 16, on routine examination of the left eye was found to have a large retinal vein passing through the macular region slightly above the fovea centralis, then dipping down almost directly and draining off into the inferior temporal vein. This case can be considered almost a mirror image of the case that I shall report. The most recent case is one reported by Nakashima [4] in 1921. I could not obtain

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Read before the Section of Ophthalmology of the New York Academy of Medicine, May 16, 1938.

1. Bohn and von Davidoff, cited by Fuchs, E.: Textbook of Ophthalmology, translated by A. Duane, ed. 4, Philadelphia, J. B. Lippincott Company, 1911, p. 541, fig. 247. Leber, T.: Die Circulations- und Ernährungsverhältnisse des Auges, in von Graefe, A., and Saemisch, E. T.: Handbuch der gesamten Augenheilkunde, ed. 2, Leipzig, Wilhelm Engelmann, 1911, pt. 2.

2. Mauthner, L.: Lehrbuch der Ophthalmoscopie, Vienna, Tendler & Company, 1869, p. 249.

3. Randall, B. A.: A Large Retinal Vein Crossing the Macular Region, M. News, Philadelphia **50**:259, 1887.

4. Nakashima, M.: Anomalous Artery in the Region of the Macula Lutea, Nippon Gankwa Gakukwai Zasshi, October 1921; abstracted, Klin. Monatsbl. f. Augenh. **69**:159, 1922.

the original article, and so I must quote from a brief abstract in the *Klinische Monatsblätter fur Augenheilkunde*. This reports the presence of a branch of the lower temporal artery which passed through the fovea. The patient, a 19 year old youth, was conscious of a linear scotoma in the field of vision going through the point of fixation.

These 3 cases are all that I could find in the literature that resemble my case in any way. In a series of studies of the branching of the retinal blood vessels in 100 cases by Jensen,[5] he described only 1 case in which he saw an inferior temporal artery dividing and sending one branch above and one branch below the macula, very close to the fovea. The interesting thing about all these cases and my own is that the blood vessels that go through this region all come from the inferior temporal artery and vein.

REPORT OF A CASE

A girl of 19 came to the ophthalmic clinic of the Mount Sinai Hospital to have her glasses changed. She had no other symptoms or complaints. Vision in the right eye was 20/40 and was improved to 20/20 with a —0.37 sphere ⌒ —0.50 cylinder, axis 15. Vision in the left eye was 20/30; with a —0.62 cylinder, axis 165, it was improved to 20/20. Examination of the eyes revealed no abnormalities aside from the refractive error and the condition to be described in the retina. In the right fundus a tributary of the inferior temporal vein was seen to come from the macula. This blood vessel was of such unusual thickness that it looked like a continuation of the main vessel. It approached the fovea directly from the temporal region of the retina. The foveal reflex seemed to be double, one above and one below the vein. As the vessel left the fovea it took a short curve upward and then ran obliquely downward and nasally. At a distance of about 2 disk diameters from the disk it joined the main vessel, which then coursed upward and nasally to the disk. It was not accompanied by an artery until it reached the inferior temporal vein. The unusual course and caliber of this vessel is well shown in figures 1 and 2. The double foveal reflex could also be seen in the slight dipping of the vessel in the macular region. The light colored areas surrounding the macula were due to light reflexes in the fundus. The patient was entirely unaware of the presence of this vessel, and the reason for this was found when its course was plotted on the stereocampimeter.

The vessel was plotted after the method so ably described by Evans.[6] A small object made of silver wire and measuring 0.27 mm. at its tip was used. The vessel could be plotted from the disk all the way to and beyond the macula. At the fovea, the angioscotoma was found to be above the point of fixation. Hence the true fovea was the light reflex above the vessel, so that the patient was looking over it all the time and was consequently unaware of its presence. It is just as though one were to hold one's forefinger directly below the eye and look over it. A photograph of this angioscotoma is illustrated in figure 3.

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5. Jensen, V. A.: Studies on the Branching of Retinal Blood Vessels, Acta ophth. **14**:100, 1936.

6. Evans, J. N.: An Introduction to Clinical Scotometry, New Haven, Conn., Yale University Press, 1938.

Fig. 1.—Photograph of the fundus showing an anomalous retinal vein, a branch of the inferior temporal vein going directly across the macula.

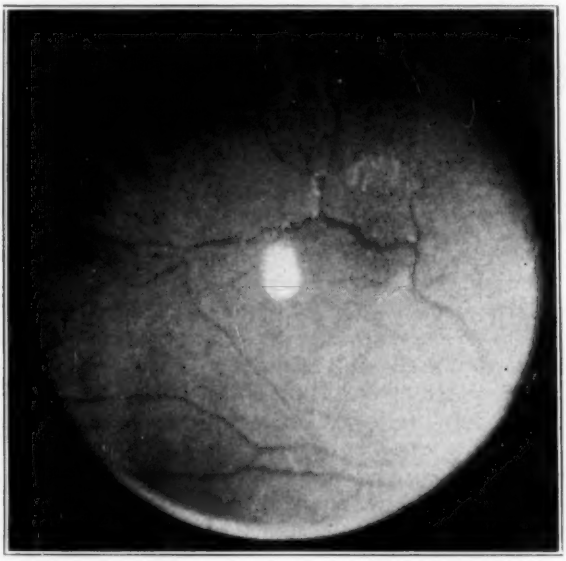

Fig. 2.—Photograph of the foveal region showing the vein going directly across the macula and causing a double foveal reflex.

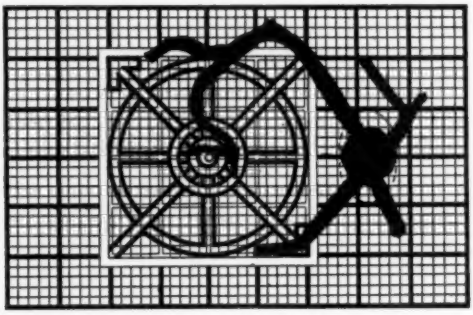

Fig. 3.—Anomalous retinal vein going across the macula and the small tributary which goes directly above the point of fixation, as demonstrated by Evans' method of angioscotometry.

COMMENT

Fundamentally, it is of the greatest importance that there is no obstruction to the passage of light stimuli to the macula. Hence, one of the conditions for the development of the macula must have been the removal of all the opaque structures from in front. The hyaloid system and the vasa hyaloidea present in the vitreous in embryonic life disappear even before the eye begins to function—before birth. The retinal blood vessels which begin to appear toward the end of the fourth month present an additional hazard. Nevertheless, the main temporal vessels curve above and below the macula, sending in numerous branches of a smaller caliber to supply this important area. In addition, there are usually separate macular vessels of smaller caliber that also go directly to the macular region from the optic disk, namely, the superior and inferior macular artery and vein. The central area of the eye is thus assured of an abundant blood supply from three sources: (1) the superior temporal artery, (2) the inferior temporal artery and (3) the macular arteries. Occasionally the cilioretinal artery replaces or is present in addition to the macular artery. Nevertheless, in spite of this extremely adequate blood supply, large blood vessels almost never cross the macula.

It is interesting to speculate why this should be so. The larger blood vessels of the retina are present in the nerve fiber layer, directly beneath the internal limiting membrane. They give off branches and capillaries which are distributed to the ganglion cell layer, the internal molecular layer and the internal nuclear layer. No branches of the retinal system go beyond this last layer. In the macular region, all of these so-called cerebral layers of the retina are gradually thinned out, and at the fovea they are completely absent for a diameter of 0.4 to 0.5 mm. This may be one explanation for the absence of blood vessels at the macular region.

Another explanation may be found in a study of the comparative anatomy of retinal circulation in different vertebrates. In some fish and snakes, in which vision is a minor sensory function, there is no true retinal circulation but a system known as a membrana vasculosis retinae, which is really in the vitreous and rests on the surface of the retina. In birds, on the other hand, in which the eye has reached its highest development, there is no retinal circulation. All the blood vessels are concentrated in a membrane which juts out from the disk into the vitreous, known as a pecten. In man an intermediate stage is seen, the retina getting a goodly share of the circulation from the central retinal arteries and its branches; but the distribution is such that no blood vessels cross the macular region which might interfere with its function.

How, then, may one account for an aberrant blood vessel in this region? It may have been laid down at a time when the macular region was not fully developed. The development of the macula is retarded between the third and the eighth month embryologically. It is during this time that the retinal circulation develops and ramifies throughout the cerebral layers of the retina. A large blood vessel which had been laid down during this stage would not be so readily swept aside at a later stage, when the fovea and macula developed fully.

It is difficult to understand why the anomalous blood vessels in the macula that have been reported up to now should come from the inferior temporal artery and vein.

SUMMARY

A case of an anomalous retinal vein in the right fundus of a girl of 19 is presented. This vein, a tributary of the inferior temporal vein, passes directly across the macular region and dips slightly below the fovea. The vessel was plotted by angioscotometry up to and beyond the fovea. An attempt to explain this anomaly is made.

VACCINIA OF THE EYES

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Since Jenner first introduced vaccination in 1796, accidental infection of the lids, conjunctivas or corneas has been intermittently reported. Bedell [1] could find only 93 cases up to 1920, but since then several have been added, as summarized by Folk and Taube [2] in 1933, bringing the total to 99 cases. The infection in only about 25 per cent of these was due to autoinoculation; that in the remainder was due to contact with persons who had been recently vaccinated against smallpox. The infection in the cases reported by Bedell and by Folk and Taube was of the latter type. Folk and Taube showed experimentally with rabbits that vaccinia blepharitis and conjunctivitis can occur as a result of contact alone of the margins of the lids with the serum from the vaccination pustule. However, in cases of vaccinia of the skin of the lids, more than mere contact is necessary; an abrasion of the skin, however slight, is essential.

When the margins of the lids are involved, the ulcerations which form have rather thick edges, but the ulceration itself is shallow. The floor of the ulcer has a yellowish, tenacious membrane, which is fairly glistening, due to the tears which collect over it. The resulting edema of the skin of the lids is terrific, often closing the eye completely, so that examination of the cornea is impossible. If the conjunctiva alone is involved, the reaction in the lids is less marked. At times the skin of the lids at some distance from the margins of the lids is affected, and in these cases a typical vaccinia vesicle develops. This goes on to pustule formation, with the development of a scab, which drops off in about seven days, leaving a pale scar.

Infection of the conjunctivas and lids of man directly from cows with cowpox also occurs, but according to Meder [3] this is less frequent than infection from a vaccination pustule. The lesion in these cases heal in six to eight weeks without leaving any scars in the conjunctiva.

1. Bedell, A. J.: Multiple Vaccination of Eyelids, Am. J. Ophth. **3**:103, 1920.

2. Folk, M. L., and Taube, E. L.: Vaccinia of the Eyelids and Conjunctiva, Am. J. Ophth. **16**:36, 1933.

3. Meder, E.: Ueber einige Fälle von Uebertragung echter Kuhpocken auf Menschen, zugleich ein Beitrag zu den Bindehauterkrangungen durch Kuhpockenstoff, Veröffentl. a. d. Geb. d. Med. Verwalt. **9**:407, 1919.

Meder expressed the belief that the conjunctival involvement is not secondary to the infection of the lids but primary and coincidental. He cited Cruickshank, Blochmann, Gineste, Gelhausen, Purtscher, Rost, Snell and others who reported cases of cowpox of the eyes in human beings as a result of direct inoculation from cows.

Involvement of the cornea occurs in both types of infection, but it is much less common than involvement of the conjunctivas and lids, as it occurred in less than 1 per cent of the total number of cases. When it develops from contact with a vaccination pustule it may be one of three types, as described by Duke-Elder [4] who cited Toulant, Schirmer and Sinaiko. The marginal form is really an infiltrate which clears up quickly after vascularization. The ulcerative type forms a true pustule and may perforate; this is the most serious type. The disciform type is sluggish but usually heals well after a fairly long course.

REPORT OF CASES

CASE 1.—J. P., a 5 year old boy, was vaccinated against smallpox on the upper part of the left arm on June 3, 1939. Nine days later the upper lid of the right eye began to swell, and the next day a red spot was noticed by the mother near the left eyebrow. Examination on this day revealed a small vesicle in the region of the left eyebrow nasally, with some erythema of the surrounding skin. This was not tender or painful. The right eye was shut tight owing to marked edema of the skin of the upper and lower lids. There were three small ulcerated areas at the margin of the upper lid nasally and one larger area temporally. The base of each ulcer was yellowish and glistening. There was only slight redness of the adjacent tissues. As much of the conjunctiva as could be seen was quite injected, but the cornea could not be examined. There was no pain or tenderness. The temperature was 99 F. by mouth. Wet dressings and petrolatum were used, but the next day the swelling of the lids was more pronounced and the ulcers were progressing. The preauricular lymph glands were palpably enlarged and somewhat tender. Sulfanilamide by mouth was prescribed because it has been used successfully in aborting the eruptive stage of smallpox. The dose was 20 grains (1.39 m.) daily combined with an equal amount of sodium bicarbonate. Local treatment was continued. The temperature for the next four days was never higher than 99.5 F. by rectum, and the swelling of the lids had receded enough in two days to afford a view of the cornea. This was found to be uninvolved. The dose of sulfanilamide and sodium bicarbonate was reduced to 10 grains (0.65 Gm.) daily for the next four days, and then the administration was discontinued. At this time the ulcers of the margins of the lids were entirely healed, leaving no scar. The tiny vesicle of the left brow had dried completely, leaving a tiny whitish area. The vision of each eye was 20/20 with a + 1.00 cylinder, axis 90.

CASE 2.—B. M., the 5½ year old daughter of a physician, was vaccinated for smallpox on the upper part of the left arm on July 20, 1939. On July 31 redness of the conjunctiva of the right eye and a temperature of 100 F. by rectum

4. Duke-Elder, W. S.: Text-Book of Ophthalmology, St. Louis, C. V. Mosby Company, 1938, vol. 2, p. 1907.

were reported by the father, Dr. P. A. Marin. He also observed swelling and tenderness of the right preauricular lymph gland. Two successive smears of the conjunctival secretion were negative, although he did note that there was little if any secretion, the discharge being serous and not purulent. He instituted the administration of sulfanilamide by mouth, 20 grains daily with an equal amount of sodium bicarbonate. I saw the child August 2, at which time there was moderate edema of the upper and lower lids of the right eye with pronounced edema of the bulbar conjunctiva. There was no involvement of the margins of the lids or of the cornea, and a slight flaky secretion was present. There were no vesicles of the skin of the lids or brow. Local treatment with a boric acid solution and petrolatum was advised plus the sulfanilamide therapy. On August 7 the swelling of the lids was gone, and the administration of sulfanilamide was discontinued. Two days later the eye was entirely white, and the vision of each eye was 20/20. At no time after the administration of sulfanilamide was begun was the temperature above 99 F. by rectum.

COMMENT

There are several things of interest that these cases suggest. First, it is to be noted that in both cases the upper part of the left arm was the site of the inoculation for smallpox and also that in both cases the right eye was involved. Grüter [5] has investigated the relation between general body immunity and the immunity of the eye. He stated that general body immunity for smallpox confers immunity on the eye and further that the immunity of the eye is greater the nearer to the eye the vaccination is performed. It seems that the 2 cases reported here bear out this contention to some extent, because the vaccinations were both nearer to the left eye and in both cases the left eye was spared.

Another fact which has been pointed out is that the secondary infection runs its course more quickly than the primary reaction to the inoculation and the longer the lapse of time between the primary and the secondary inoculation the more quickly does the secondary infection run its course and heal. In the first case there was a nine day interval between the vaccination and the ocular autoinoculation, and in the second case, an interval of eleven days. The patient in the first case had much more ocular reaction, as evidenced by the edema and the ulceration of the lids. The infection in the second case was much more mild and there was less reaction from the beginning.

It is true that the infection in a great majority of cases heals in eight to ten days with no sequelae, although corneal ulcers with perforation, symblepharon and deformities of the lids have been reported. The infection in the 2 cases here reported healed entirely in seven and eight days, respectively, but this is no marked improvement over the usual

5. Grüter, W.: Kritische und experimentelle Studien über die Vaccineimmunität des Auges und ihre Beziehungen zum Gesamtorganismus, Arch. f. Augenh. **70**:241, 1911.

course. It would then seem that the sulfanilamide, if it helps at all, does not shorten the usual course sufficiently to warrant one drawing any conclusions about its value in these cases. However, the use of sulfanilamide should be kept in mind as a possible aid in the treatment of vaccinia of the eyes.

SUMMARY

Two cases of vaccinia of the eyes due to autoinoculation are reported.

In 1 of the cases the margins of the lids were primarily involved; in the other, the conjunctiva.

The patients in both cases had been vaccinated against smallpox on the upper part of the left arm and both had involvement of the right eye.

Both patients were cured quickly without any complication or sequelae.

The use of sulfanilamide may or may not have been of value.

Clinical Notes

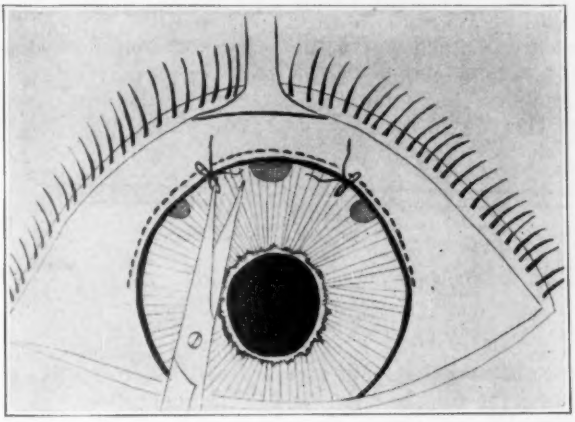
REMOVAL OF SCLEROCORNEAL SUTURES

A. C. Hilding, M.D., Duluth, Minn.

Apropos of a recent article [1] on operations for cataract in which sclerocorneal sutures were used, I have been asked when and how to remove the sutures.

Removal of such sutures is not without danger. Should the patient suddenly roll the eyes upward while an uncut suture is being held in the grasp of a pair of forceps, both pain and damage might result.

The following procedure for removal of these sutures has been developed: They are left in place ordinarily about a week. If they seem



Position of scissors for safe removal of sclerocorneal sutures.

to cause irritation, they may be removed as early as the fifth day. If there is no irritation, they may remain as long as eight or nine days. The sutures are removed in the operating room in good light under reasonably aseptic precautions, with the patient lying on a wheeled stretcher. It is not necessary for him to be on the operating table. The eye must, of course, be anesthetized. When ready to cut the sutures, the surgeon holds a scissors in his right hand and a lid retractor in his left. The upper lid is lifted by means of the retractor, and the suture is cut close to the cornea with the tips of the scissors. The tip of one blade may be gently inserted slightly under the suture, as shown in the accompanying illustration. It is important that the scissors be directed upward and not parallel with the incision, so that if the patient should suddenly roll the eye upward before the suture is cut it cannot become

1. Hilding, A. C.: Mechanics of Prolapse of the Iris in Cataract Operations: Clinical Observations and a Method of Prevention, Arch. Ophth. **22**:171-176 (Aug.) 1939.

caught on the blade but will slide off. Should the suture become caught on the blade in case of movement, a vigorous and damaging tug on the suture might result. After the suture is cut, the surgeon lays aside his scissors, picks up a small thumb forceps and, grasping the suture above the incision, removes it by pulling toward the center of the cornea.

A SERRATED DISCISSION NEEDLE

FRANK CLAVELOUX PARKER, M.D., NORRISTOWN, PA.

Operators conversant with the needling operation for secondary cataract or for iridocapsulotomy or iridotomy know that owing to the texture of the membranes involved or to their flexibility or mobility it is at times difficult to make the proper cut. The discission needle will slide over the margin of the capsule and push the capsule aside instead of cutting through it, as is necessary for a good opening. In order to secure a good aperture in the capsule, a triangular cut as advocated by Ziegler should be made.

The failings of the smooth-edged knife needle were responsible for the thought that an instrument with a serrated edge might overcome

Serrated discission needle.

some of these shortcomings and give a "hold," so to speak, as the needle is drawn across the membrane. As a consequence, the discission needle herein described is offered.

A good knife needle should have a proper point for the puncture and should be sharp. A most important feature is that the shaft should snugly fill the small wound so as to prevent the escape of aqueous and yet not bind or jam as the instrument is slid back and forth through the wound. The shaft should be of uniform thickness throughout its entire length and should not taper. A tapered shaft which is too thin at the small portion permits escape of aqueous, while the thick end may jam in the wound. The shaft should slide freely, yet snugly plug the wound opening. Its action might be likened to the sliding back and forth of a piston in the cylinder of a motor or to the plunger in a glass hypodermic syringe. If this cylinder or plunger tapers any, it will not work properly.

The discission needle I am describing has a point adapted for easy puncture. (Too many needles have a sickle-shaped point.) Two millimeters from the point a serrated edge continues for the length of the

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Presented at the Willis Hospital Clinical Conference, Philadelphia, March 26, 1940.

blade. The shaft complies with the description cited, that is, it is of uniform diameter throughout.

I have found this instrument to perform nicely, especially when cutting through a tough iris and capsule bound together in a tight mass.

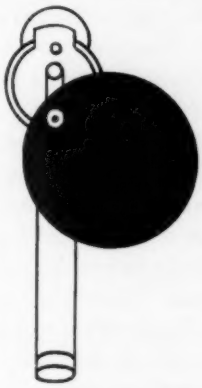
This discission needle is not a remedy for all the ills associated with the needling operation, but I feel that it does have some advantages over a smooth blade in many instances.

The E. B. Meyrowitz Company makes the needle.

A SCREEN FOR OPHTHALMOSCOPIC EXAMINATION

BENJAMIN FRIEDMAN, M.D., NEW YORK

A barrier between the nose and mouth of the patient and those of the oculist is of obvious mutual benefit for esthetic and hygienic reasons.



A screen for ophthalmoscopic examination.

The screen shown consists of a disk of black bakelite, 8.25 cm. in diameter, which is attachable by means of a spring clip to the vertical carrier post on the back of any standard opthalmoscope head. The disk pivots on a spring washer and remains adjusted in whatever position may be required for the examination of either the right or the left eye. To prevent scratching the surface of the ophthalmoscope, the prongs of the clip are covered with rubber.

This screen should be particularly useful to the oculist who can employ only one eye for his ophthalmoscopic examination and who must therefore come into undesirable proximity to the patient. The apparatus is readily detachable, light and inexpensive, is conveniently carried in the pocket and may be sterilized by immersion in an antiseptic solution. The screen was made by J. Brandenberg & Co., New York.

Ophthalmologic Reviews

EDITED BY DR. FRANCIS HEED ADLER

PATHOLOGIC CONDITIONS OF THE CORNEA

I. DISTURBANCES OF THE EPITHELIUM, ENDOTHELIUM AND BOWMAN'S AND DESCEMET'S MEMBRANE

BENJAMIN RONES, M.D.

WASHINGTON, D. C.

The description of corneal disease has been exhaustively elaborated in all textbooks of ophthalmology. Unfortunately, the classification of these conditions is usually based on their clinical appearance rather than on an etiologic or pathologic basis. This is due partly to the fact that the exact causation is frequently unknown and also that pathologic material is usually not available in the beginning stages of many of these conditions. Nevertheless the confusion results chiefly from the desire to label these conditions on the basis of their clinical appearance alone, thus producing a variegated terminology applied to stages of the same disease process. In view of the newer knowledge of corneal metabolism and respiration that has been revealed in recent years, it is profitable to review the pathology of this important transparent tissue of the eye. This initial paper will deal with the surface epithelium and endothelium, together with their adjacent layers, Bowman's and Descemet's membranes.

ROLE OF THE EPITHELIUM AND ENDOTHELIUM IN THE PHYSIOLOGY OF THE CORNEA

The cornea is an avascular tissue the function of which depends on the maintenance of its transparency, and any metabolic disturbance that impairs this property becomes of serious import. This transparency is chiefly dependent on its water content, which is controlled by its delimiting epithelium and endothelium. So long as the water content remains within certain limits, the cornea will remain transparent, but if there is an increase or decrease of fluids beyond these limits, opacities develop.

From the Registry of Ophthalmic Pathology, Army Medical Museum.

Based on an instructional course at the Forty-Fifth Annual Meeting of the American Academy of Ophthalmology and Otolaryngology, Chicago, Oct. 8 to 13, 1939.

The nutrition of the cornea is served by a process of simple diffusion of fluids from the vascular plexus around the limbus. Since there are no preformed channels in the cornea, the fluid diffuses directly through the tissue substance. Although the aqueous is also a dialysate containing the same constituents as this corneal fluid, it does not pass into the cornea normally, for the intact endothelium is able to prevent the passage of water. This is due to the fact that the corneal tissue possesses the property of irreciprocal permeability, whereby water, most of the ionized diffusible substances and the alkaloids can pass through it only in the direction from the surface epithelium toward the anterior chamber.[1] This selectivity of permeability is entirely dependent on the anatomic and functional integrity of the epithelium and endothelium. If the latter is injured either by trauma or disease, fluid readily passes through the freely permeable Descemet's membrane into the stroma, which swells and becomes opaque. That this edema need not result in a permanent opacity is demonstrated by its disappearance when the damaged endothelium again becomes healthy and intact.

Diffusion through the intact epithelium is slow but is of the greatest importance in the physiology and therapeusis of the eye. Thus drugs such as atropine, physostigmine salicylate and potassium iodide when placed in contact with the cornea can rapidly be detected in the anterior chamber. The fact that this is a transcorneal diffusion and not an absorption through the limbic plexus is shown by the occurrence of diffusion even when the limbus and conjunctiva are protected, as by a petrolatum ring. The diffusion can be accelerated by the employment of osmotic forces, such as hypotonic solutions, or by electric forces, as in iontophoresis.[2] When the epithelial barrier to absorption is impaired or destroyed, diffusion becomes much more rapid and nonselective, so that substances like methylene blue, fluorescein and blood serum are now able to pass through. In such manner diffusion is accelerated by the action of cocaine hydrochloride, which causes both a drying of the epithelium and a toxic action on the nerve endings. A similar effect on the nerve endings is common to all anesthetics, for the normal metabolism and permeability of the epithelium are dependent on the functional integrity of the trigeminal nerve endings. When the ophthalmic division of the fifth nerve is sectioned, there occurs the ulcer formation of keratitis neuroparalytica, which, according to Tagawa,[3] results from the damage to the trophic fibers present in the fifth nerve.

1. Duke-Elder, W. S.: Text-Book of Ophthalmology, St. Louis, C. V. Mosby Company, 1938, vol. 2.

2. Kronfeld, P. C.: Introduction to Ophthalmology, Springfield, Ill., Charles C. Thomas, Publisher, 1938.

3. Tagawa: Ueber die Beschaffenheit der Hornhautoberfläche nach Trigeminusdurchschneidung, Arch. f. Augenh. **102**:231, 1929.

Since there are no blood vessels within the cornea, a respiratory mechanism must be present for the transportation of oxygen and carbon dioxide. Deficiency of oxygen or faulty elimination of carbon dioxide will result in necrosis and opacity formation in the cornea. This gaseous exchange through the cornea is regulated by an irreciprocal permeability, just as with fluids. Oxygen is able to pass from the air, through the epithelium toward the anterior chamber, while carbon dioxide can only diffuse outward to the air. Thus the endothelium, which requires a considerable amount of oxygen, is able to utilize the supply from the adjacent aqueous as well as that diffusing to it from the surrounding atmosphere.[4] Gundersen[5] cited Bessey's work with the Warburg respirator in demonstrating that the metabolic activity of the cornea is rapid, as measured by its oxygen consumption. Gundersen placed corneal buttons in the anterior chamber and found that the epithelium disappeared while the endothelium proliferated, indicating that the oxygen content of the aqueous is not sufficient for the epithelium. He concluded from these experiments that if the epithelium cannot live in the aqueous and if its supply of nourishment from the blood can be almost completely destroyed by peritomy without affecting its existence, then tears fall under direct suspicion as the nutritive vehicle. He expressed the belief that it is probable that the epithelium derives its nutrients chiefly from the lacrimal secretion and utilizes oxygen directly from the surrounding air.

It is obvious, therefore, that in order to maintain respiration and control of fluid transference, there must be no impairment of continuity or functional integrity of the corneal epithelium and endothelium.

ANATOMY

A brief review of the histologic structure of these layers is necessary in order to understand better their pathologic alterations. The anterior surface of the cornea possesses great smoothness and regularity. The stratified pavement epithelium is of uniform thickness and is made up of five or six layers of cells. The deepest layer, the "basal cells," consists of a single layer of short cylindric cells, standing with a flat base directly on Bowman's membrane, to which they are only loosely attached and from which they can therefore be easily separated. Anterior to this are the three layers of "wing cells," the edges of which are drawn out into the shape of wings. Wing cells of the outermost layer assume a flatter shape and merge into the two layers of "surface cells," which are large

4. Adler, F. H.: Clinical Physiology of the Eye, New York, The Macmillan Company, 1933.

5. Gundersen, T.: Vacular Obliteration for Various Types of Keratitis: Its Significance Regarding Nutrition of Corneal Epithelium, Arch. Ophth. **21**:76 (Jan.) 1939.

in surface expanse but thin, with flattened nuclei. These epithelial cells are linked together by protoplasmic bridges, as in the epidermis. The spaces between the bridges are enlarged when fluid accumulates there, and leukocytes often wander into them.

Bowman's membrane is a clear, homogeneous layer extending to the limbus, where it ends abruptly. It is wholly structureless, showing neither cell nuclei nor fibrillation and being absolutely smooth on section. It contains many "holes" through which pass the perforating branches of the corneal nerves. The anterior surface of this membrane is sharply defined, but posteriorly it merges with the superficial lamellas of the substantia propria, from which it cannot be detached. Also it differs from the fibrillar lamellas only in its homogeneity, for their staining reactions are entirely similar. Salzmann [6] consequently regarded Bowman's membrane as a specially modified superficial substantia propria.

Descemet's membrane differs from this in that it is a typical "glass membrane," of great firmness and elasticity. It is a homogeneous, structureless membrane, which gapes when cut, the ends showing a tendency to curl up. In its staining reaction there is a distinct difference from Bowman's membrane and the stroma, for it takes an elastic tissue stain. It also differs from Bowman's membrane in that it is readily separable from the substantia propria and further in its regeneration after pathologic destruction. Descemet's membrane is probably formed as a secretion from the endothelial cells, just as the similar "glass membranes," the lens capsule and the lamina vitrea are secretory products of the lens epithelium and retinal pigment epithelium, respectively.

The endothelium extends over nearly the entire surface of Descemet's membrane. It is a single layer of flat hexagonal cells, sharply defined and rich in protoplasm, thus resembling epithelium more than endothelium. On the basis of its embryologic development it should more appropriately be called mesothelium.

GENERAL PATHOLOGIC BEHAVIOR

The corneal epithelium is the initial line of defense against trauma and primary corneal infections. At first glance it would seem that it could not serve its purpose efficiently, because of its exposed position and low temperature, together with its fragile structure and insecure anchorage to Bowman's membrane. However, owing to its great sensitivity it is well protected against trauma, and by virtue of the imperviousness of its superficial cells it is safeguarded against all external

6. Salzmann, M.: The Anatomy and Histology of the Human Eyeball, Chicago, University of Chicago Press, 1912.

infections, with the possible exception of the diphtheria bacillus and the gonococcus. If this surface continuity is broken, however, disease may easily enter the stroma, for Bowman's membrane is freely permeable to toxins.

Disease having entered the cornea, its spread is influenced by the varying resistance of the different tissues as well as by their chemical constitution and metabolism. Bowman's membrane is easily destroyed both by suppuration and by the invasion of tissue, as in pannus and pterygium. Descemet's membrane, however, is highly resistant. Even when the entire thickness of stroma is destroyed by ulceration, Descemet's membrane may form a floor which will bulge under the influence of intraocular pressure and finally rupture. The influence of chemical constitution on the localization of disease is seen in the deposition of silver in Descemet's membrane in argyria and of calcium in Bowman's membrane.

PIGMENTATION

In many elderly persons the posterior corneal surface is seen to be dusted with fine golden-brown pigment granules, which have migrated from the pigment layers of the iris and ciliary processes. This migration of uveal pigment is accentuated in such pathologic states as uveitis, diabetes and glaucoma. At times the aqueous currents will deposit the granules in a vertical arrangement called Krukenberg's spindle. Histologically, the pigment granules are seen to lie on the posterior surface of the endothelium but also are found within the cells, which have limited phagocytic properties.

Hematogenous pigmentation of the cornea can occur after massive hemorrhages in the anterior chamber, by absorption of pigment through Descemet's membrane. At times such a hemorrhage following trauma can produce detachment of the endothelium or Descemet's membrane.

A much rarer type of corneal pigmentation is the Kayser-Fleischer ring seen in hepatolenticular degeneration. The pigment has as yet not been identified, but examination has shown it to be made up of fine, closely packed granules beneath the endothelium, partially penetrating Descemet's membrane. The corneal membranes may also be involved in a generalized melanosis, either congenital or acquired.

ATROPHY AND HYPERPLASIA

Thinning of the epithelium by atrophy is seen in cases of scarring of the cornea with insufficient nutrition of the epithelium. The superficial flat cells lose their nuclei and become thin scales, while the middle polygonal cells change into flat cells. The cylindric basal cells become shorter and finally flat. Near the margin of an ulcer the epithelium may also undergo a progressive thinning, which at times is combined with necrosis, so that it is changed into a homogeneous mass without nuclei.

Fuchs [7] has thoroughly described the development of corneal staphyloma. In its earliest stages it is composed of prolapsed iris covered by epithelium alone. The latter proliferates, filling up all the spaces and becoming greatly thickened, with numerous downgrowths into the underlying granulation tissue derived from the inflamed iris. The necrotic epithelium of the iris scatters its pigment, which is taken up by leukocytes and carried into the corneal epithelium.

Besides the uveal pigment, corneal scars frequently show a yellowish brown line in the epithelium, which Hanssen [8] stated is a result of

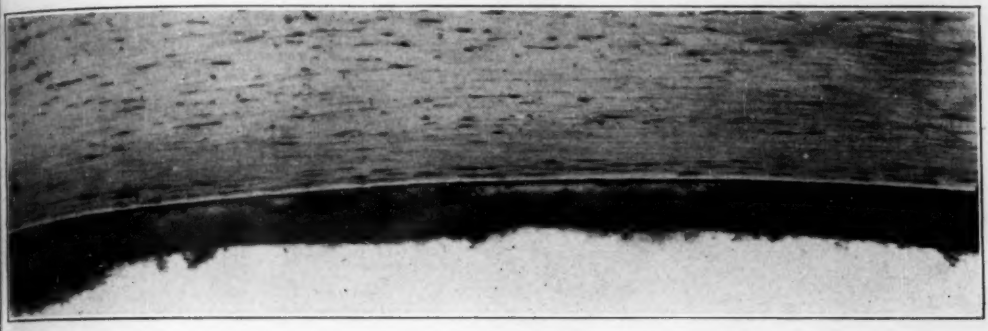


Fig. 1.—Endothelium detached from Descemet's membrane by hemorrhage; × 105.

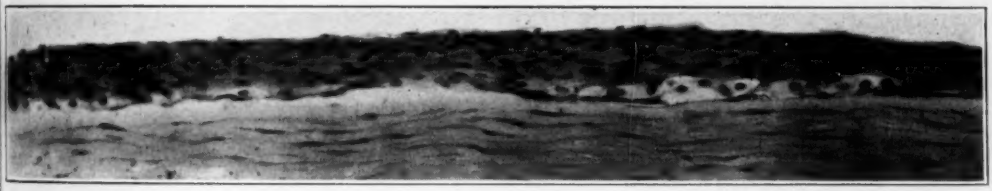


Fig. 2.—Anaplasia of the epithelium; × 201. All layers are composed of flattened nucleated cells. Edematous cells are seen in the basal layer.

deposition of hemosiderin. Among changes in old corneal scars, especially in staphyloma, a common one is an epidermoid thickening of the epithelium, with the later development of xerosis. Here there occurs a metaplasia of the corneal epithelium to an epithelium of the epidermal type. The cells of the basal layer are of cylindric form, with the upper end tending to taper off. They have a slight granular proto-

7. Fuchs, E.: Zur Anatomie des Staphyloma corneae, Arch. f. Ophth. **95**: 215, 1918.

8. Hanssen, R.: Ueber Hornhautverfärbung, Klin. Monatsbl. f. Augenh. **71**: 399, 1923.

plasm and a large, oval, well stained nucleus. Mitotic figures occur rather frequently. Above this are four to eight rows of moderately irregular polygonal cells, the surfaces of which are covered with spinelike intercellular bridges, forming the stratum spinosum or malpighian layer and gradually merging into the two or three rows of flattened cells of the granular layer. Downward prolongations of this epithelium, or rete pegs, alternate with the upward projecting vascularized connective tissue papillae. At times there is seen the development of an outermost horny layer, as in the skin. Rarely, there occurs a hyperkeratosis, with hypertrophy of this horny layer accompanied by hypertrophy of the granular layer. The more usual picture is a parakeratosis, an incomplete keratinization and the horny cells retaining their nuclei. The granular layer is usually absent or poorly developed, for the condition is due to a too rapid transformation from the prickle to the horny cells, without passing through the stage of formation of the

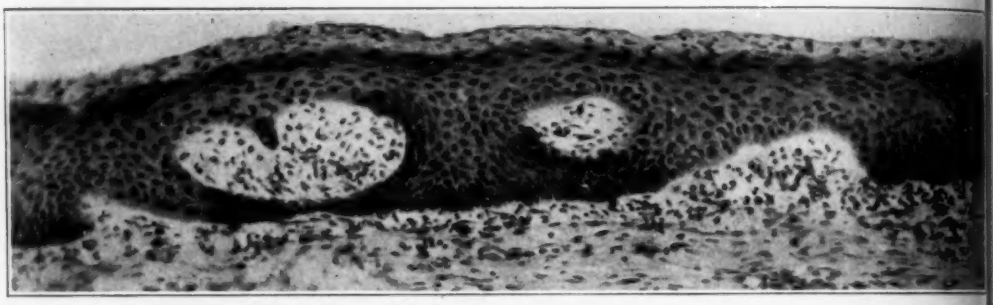


Fig. 3.—Well defined basal layer with suggestion of pegs; × 142. The malpighian and granular layers also are well defined. Superficially, there is a broad layer of parakeratosis, with nuclei still retained. There are papillae-like developments in the pannus.

granular layer. The horny cells also retain some of the characteristics of the prickle layer, usually the intercellular bridges. This causes them to be closely attached to one another, with resultant retention as thick scales, which are reluctantly desquamated. This thickening of the epithelium with superficial keratinization is often found in conditions in which constant exposure of the cornea occurs, and although such an epithelium is opaque, it offers a greater protection against infection. At other times the scars undergo hyaline and calcareous degeneration. In the former, masses of hyalin are deposited in the scar and in the overlying epithelium, while in the latter calcareous plaques develop beneath the epithelium, which dips down to undermine and surround the plaques. Resultant necrosis causes the calcareous masses to slough off, frequently leaving a surface already covered with epithelium.

Vascularization of the cornea from the periphery occurs frequently as a defensive measure against disease of this structure. In superficial vascularization, the vessels are derived from the conjunctival circulation and enter the cornea at the level of Bowman's membrane or else directly beneath the epithelium. The rupture of such a vessel may produce a subepithelial hemorrhage. If granulation tissue develops along with

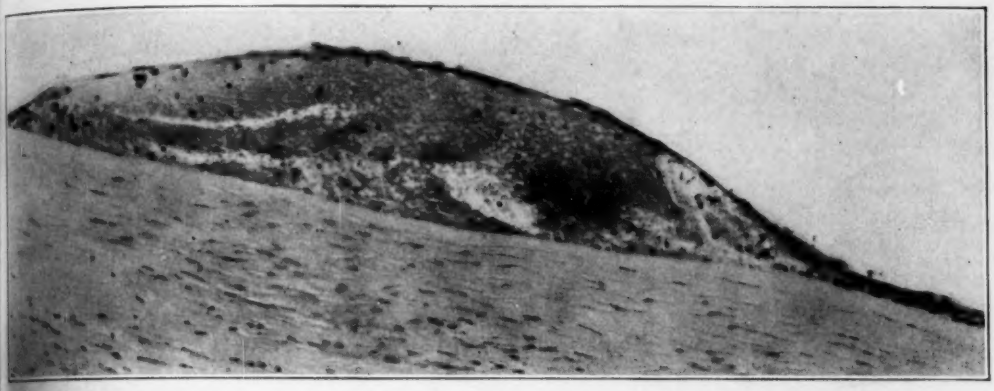


Fig. 4.—Hemorrhage beneath atrophic epithelium, resulting from rupture of a vessel in an area of superficial vascularization; × 138.

Fig. 5.—Calcification in pannus degenerativus; × 142. The epithelium is partly atrophic and partly hyperplastic.

this superficial vascularization, a mass of vascularized connective tissue, or pannus, is then formed beneath the thickened and degenerated epithelium, lying on the fragmented Bowman's membrane. Hyaline degeneration and calcareous deposition frequently occur in pannus degenerativus, and vesicles develop in the overlying epithelium.

In a previous paragraph it was explained that the endothelium could be regenerated after partial destruction. At times it assumes hyperplastic proportions, so that several layers of new cells are present.

Associated with this, there is frequently an excessive deposition of hyaline membrane, giving rise to the reduplications of Descemet's membrane. The newly formed endothelium and hyaline membrane may spread over the angle of the anterior chamber and cover the anterior

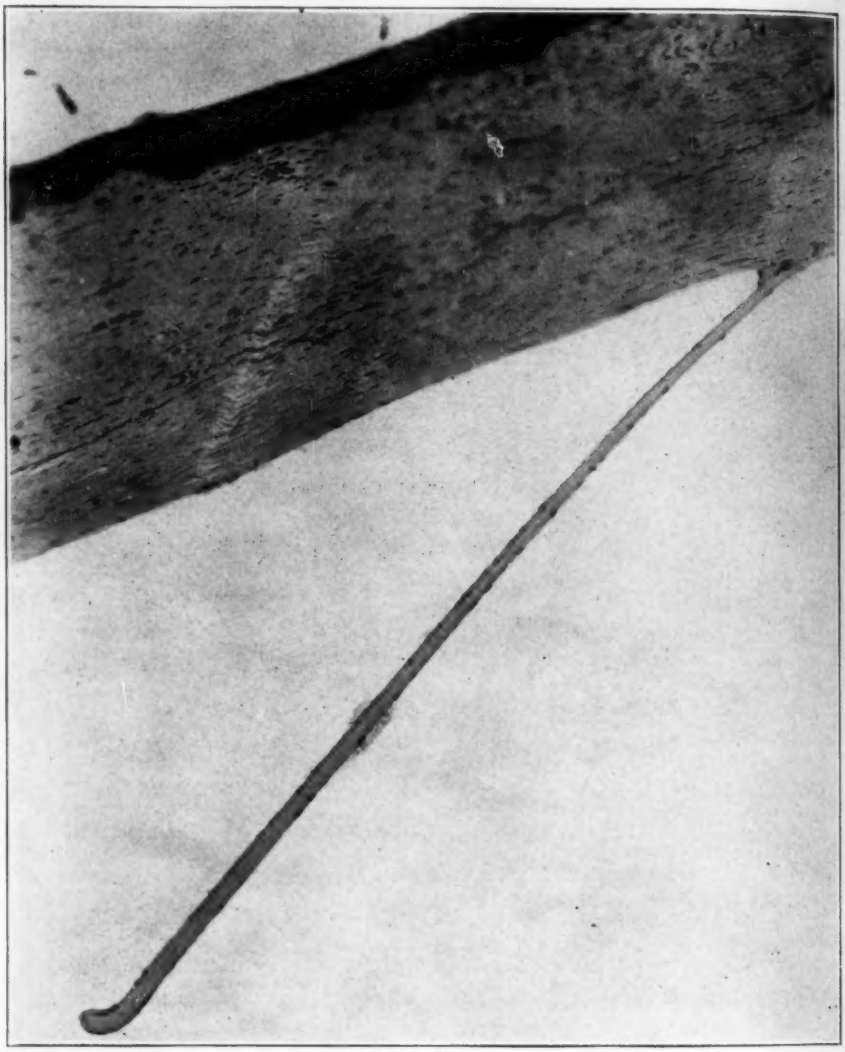


Fig. 6.—Stalklike projection of Descemet's membrane into the anterior chamber; × 100. The endothelium completely covers the stalk.

surface of the iris. Also at times there may be formed long strands of hyaline membrane covered by endothelium, which protrude into the anterior chamber or attach themselves to the surface of the iris.

DYSTROPHIES

A common senile change in Descemet's membrane is the development of hyaline excrescences. Where these protuberances are numerous and cover the central portion of the cornea, they have been given the name "cornea guttata," or endothelial dystrophy of the cornea. The endothelium becomes degenerated and is thinned over the excrescences. It has been pointed out by numerous observers that this degeneration of the endothelium allows the intraocular fluid to filter into the cornea, and the resultant changes in the epithelium and stroma give rise to the picture called epithelial dystrophy of the cornea. Here the intitial changes are an edema of the epithelium, which begins centrally and spreads peripherally. Vacuoles then form and on bursting these leave minute scars

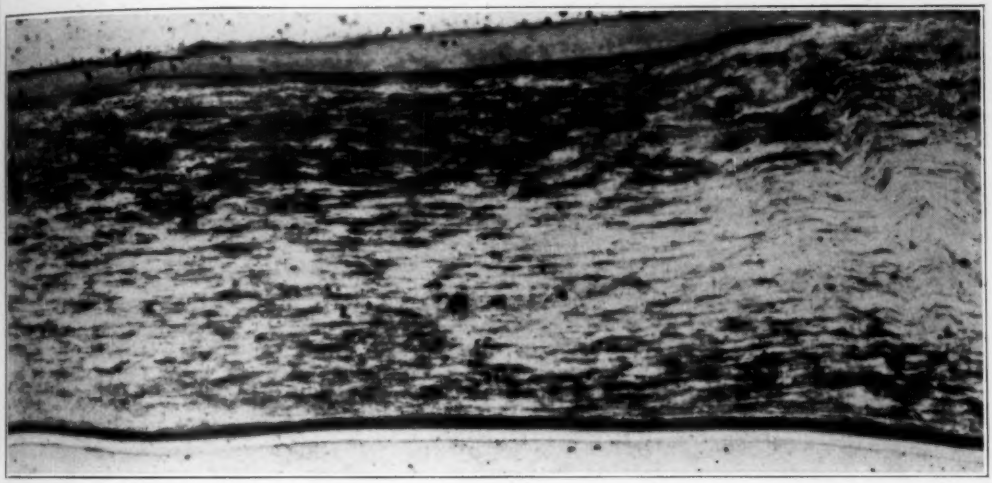


Fig. 7.—Arcus senilis. The stroma is densely infiltrated with fat. Note the heavy fat infiltration in Bowman's membrane, with its sharp peripheral demarcation. Scarlet red; × 132.

in the epithelium, which multiply and spread deeper, until the entire cornea is opaque. In the case reported by von Hippel [9] there was atrophy of the epithelium, and Bowman's membrane was replaced by a thick layer of connective tissue, or pannus degenerativus.

Band-shaped opacity, or transverse calcareous film of the cornea, shows a new formation of nonvascular fibrous tissue anterior to Bowman's membrane. The latter is broken up into short sections, the gaps being filled with fibrous tissue. Lying on the anterior surface of the

9. von Hippel, E.: Anatomische Untersuchung eines gazen Bulbus mit Dystrophia epithelialis corneae (Fuchs), Arch. f. Ophth. **128**:265, 1932.

membrane are calcareous granules. The overlying epithelium is thickened in some places and atrophic in others.

The nodular types of dystrophy are essentially disturbances of the superficial stroma, where hyaline masses are deposited. Later there occurs a destruction of Bowman's membrane and atrophy of the epithelium over the nodules.

DEGENERATIONS

Arcus senilis is the most common of all senile changes in the eyes. Takayasu,[10] using sudan III stain, demonstrated an infiltration of fat droplets both in the stroma and in Bowman's membrane. This work was confirmed by Parsons.[11] Microscopically, it can be seen that the arrangement of the fat droplets produces the clinical characteristics of the arcus. Bowman's membrane normally does not extend to the

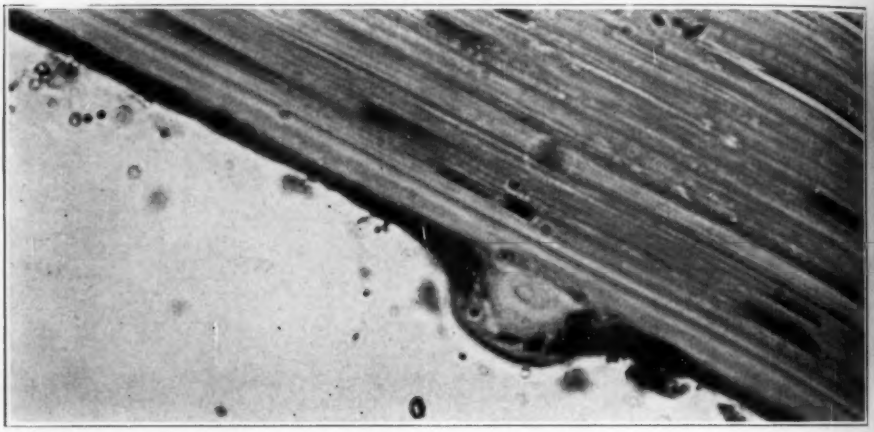


Fig. 8.—Hyaline excrescence on Descemet's membrane, covered by endothelium; × 915.

extreme periphery of the cornea. The point of termination marks the sharp peripheral border of the arcus, for the membrane is heavily laden with fat globules, while the corneal tissue peripheral to it is comparatively free and appears clear. In well advanced cases, fat globules are found not only in the stroma and Bowman's membrane but in Descemet's membrane and even in the endothelium.

Descemet's membrane loses its fairly uniform thickness with advancing years and shows areas of thickening and protuberance.[12]

10. Takayasu: Beiträge zur pathologischen Anatomie des Arcus senilis, Arch. f. Augenh. **43**:154, 1901.

11. Parsons, J. H.: Arcus Senilis, Roy. London Ophth. Hosp. Rep. **15**:141, 1903.

12. Rones, B.: Senile Changes and Degenerations of the Human Eye, Am. J. Ophth. **21**:239, 1938.

Small hyaline excrescences (Hassall-Henle warts) are seen, being analogous to the drusen of Bruch's membrane. These are found at the periphery of the membrane but more often are seen with the slit lamp to cover the entire center of the cornea (cornea guttata). Histologically, they are small hemispherical hyaline projections from the inner surface of Descemet's membrane. The endothelium over these nodular thickenings is thinned but remains intact.

Bowman's membrane does not have the hyaline structure of Descemet's and Bruch's membranes, but nevertheless hyaline deposits have been found associated with it in various pathologic conditions. These are probably due to the deposition of hyalin on Bowman's membrane rather than participation of this layer in their formation. Such masses have been described in the nodular and reticular corneal dys-

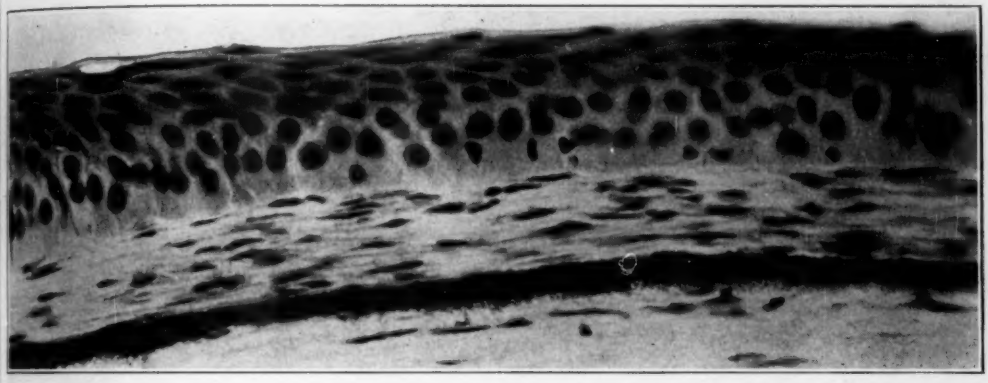


Fig. 9.—Calcification of Bowman's membrane with inflammatory fibrous tissue growing between it and the epithelial layer; × 130.

trophies. Frequently associated with them are granular depositions of calcium salts in Bowman's membrane, progressing to form masses.

Wolff and Lyle[13] described hemispherical bodies in Bowman's membrane in glaucomatous eyes. These were confirmed by Talbot,[14] who expressed the opinion that they were structureless and were probably lacuna-like spaces around the nerve fibrils. Wolff pointed out, however, that the number of bodies seen in a typical section roughly corresponds to the number of nerves which penetrate Bowman's membrane, and he suggested that they might be a hyaline degeneration of these nerve fibrils.

13. Wolff, E., and Lyle, T. K.: Hemispherical Formations in Bowman's Membrane, Proc. Roy. Soc. Med. **30**:701, 1937.

14. Talbot, J.: Histology of Bowman's Membrane in Cases of Glaucoma, Brit. J. Ophth. **22**:210, 1938.

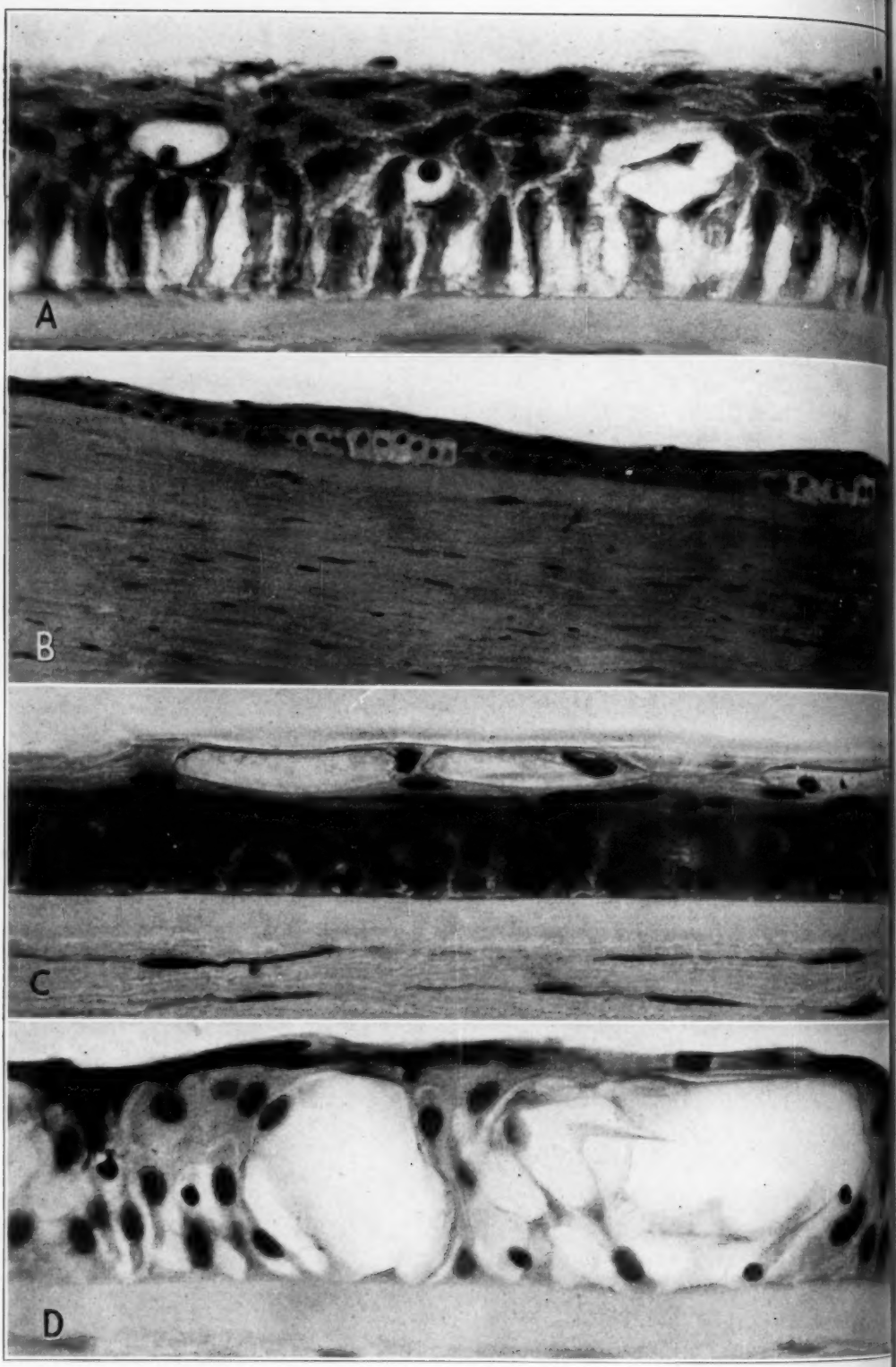


Fig. 10.—*A*, intercellular and intracellular edema of epithelium; × 600. *B*, intercellular edema in a basal layer of epithelium; × 175. *C*, vesicles in the superficial layers of epithelium; × 700. *D*, edema and vesicle formation in epithelium; × 600.

EDEMA

It was previously mentioned that corneal fluid transference is altered when the endothelium is damaged. This occurs with great frequency in inflammation of the uveal tract, in which the fluid traverses the substantia propria, passes through the nerve canals in Bowman's membrane and forms droplets between the basal cells of the epithelium. These edematous changes are seen most strikingly, however, in cases of glaucoma with increased intraocular tension. After first forming droplets in the intercellular spaces of the basal layer, the fluid passes anteriorly into the central layers, where the cells are spread apart, causing their intercellular bridges to become more pronounced. If the edema extends, the intercellular bridges separate and the spaces open into each other, forming vesicles. When the fluid remains localized in the deeper layers, the coalescent vesicles may lift the epithelium away from Bowman's membrane. Terry [15] expressed the belief that these edematous spaces occur more frequently between the basal cells and Bowman's membrane because the epithelial cells are more closely bound to each other than they are to Bowman's membrane, both by the intercellular bridges and by the interepithelial nerve fibers. The cells themselves may become swollen by imbibition and vacuoles form in them, causing some to burst. At other times the deeper cells become swollen and changed into a nearly homogeneous mass. In some cases successive layers of cells are swollen.

The fluid effused into the cellular interspaces and imbibed by the cells loosens their coherence and causes their desquamation. Single cells may be exfoliated, but in cases of severe edema whole layers are thrown off, leaving the basal layer. At other times the entire epithelium is lost, leaving a denuded Bowman's membrane. Rarely the superficial desquamating cells separate themselves clearly from the lower layers, so that the surface of the cornea remains smooth. As a rule, however, after the shedding of the superficial layers, the corneal surface is uneven. When the deeper layers remain, the cells do not appear normal, for they are not able to reach maturity since they must divide rapidly in order to replace their loss. Consequently they do not have the typical cylindric appearance but are short and cubical or else long and thin.

Leber [16] (1873) first showed that if either mechanical or chemical trauma damaged the endothelium, edema of the cornea occurred and persisted until the endothelium regenerated, although at times a permanent opacity resulted. This has been confirmed by many observers

15. Terry, T. L.: Some Physiological and Anatomical Aspects of the Cornea Affecting Its Pathology, Am. J. Ophth. **22**:153, 1939.

16. Leber, T.: Studien über den Flüssigkeitswechsel im Auge, Arch. f. Ophth. (pt. 2) **19**:87, 1873.

and is often seen after a cataract section, in keratoconus, in buphthalmos or in contusions of the eye.

Besides the aforementioned causes, edema of the epithelium may result from a number of other conditions. It is frequent in acute inflammatory conditions of the conjunctiva, particularly of the gonococcic variety. Some degree of edema of this layer is present in nearly all inflammatory and degenerative diseases of the cornea, even though it is localized to a small area. In neuropathic conditions the edema is more widespread, forming many vesicles and bullae with exfoliation. Such disturbances have also been reported by Aubineau [17] and by Marbaix [18] in patients with hypercholesteremia and consequently have been attributed to a derangement of the lipoid metabolism.

Clinically, the edema of the epithelium is best observed with the slit lamp. The epithelial layer is hazy and has a dull uneven surface. In vesicular keratitis numerous vacuoles are seen, and when these coalesce they form bullae. On staining with fluorescein, there may be many

Fig. 11.—Desquamation of atrophic epithelium; × 142.

minute green points present, or there may be large areas of staining resulting from extensive desquamation.

Edema of the endothelium is an almost constant accompaniment of deep parenchymatous disease of the cornea or of disease of the uveal tract. If due to the first cause, it is frequently associated with folds in Descemet's membrane. The edematous endothelium is well seen with the slit lamp, causing the posterior corneal surface to present minute irregularities or "bedewing."

WOUNDS AND REPAIR

In a simple abrasion of the epithelium, repair is soon affected without any nebula left behind. Owing to the marked tendency of the epithelium to level all inequalities, this filling-up of a defect occurs

17. Aubineau, E.: Oèdeme cornéen et hypercholestérinémie, Ann. d'ocul. **159**: 580, 1922; L' "oèdeme cornéen" des hypercholesterinémiques, ibid. **166**:645, 1929.

18. Marbaix: Un cas d'oèdeme de la cornée avec décollement probable de l'endothélium, Bull. Soc. belge d'opht. **64**:117, 1932.

rapidly. The initial process is a mechanical one, for the release of tension allows the cells to slide over Bowman's membrane to reach the denuded area. Mitosis is seen in the neighboring basal cells a few hours later, and the newly formed cells spread laterally over the bare surface. The rapidity of this process is shown by the fact that Gundersen [5] observed the entire cornea to be recovered with new epithelium in from three to four days. After the new epithelium has become consolidated, it cannot be detected histologically from the older neighboring cells. In rare cases, however, the new epithelium formed over an abraded area fails to acquire its necessary attachment to Bowman's membrane, and it later becomes raised into vesicles, which rupture and form fresh defects. These recurrent erosions have been felt by Gifford [19] to be due to a neurotrophic disturbance. The trauma apparently initiates the changes, but the epithelial cells are left weak

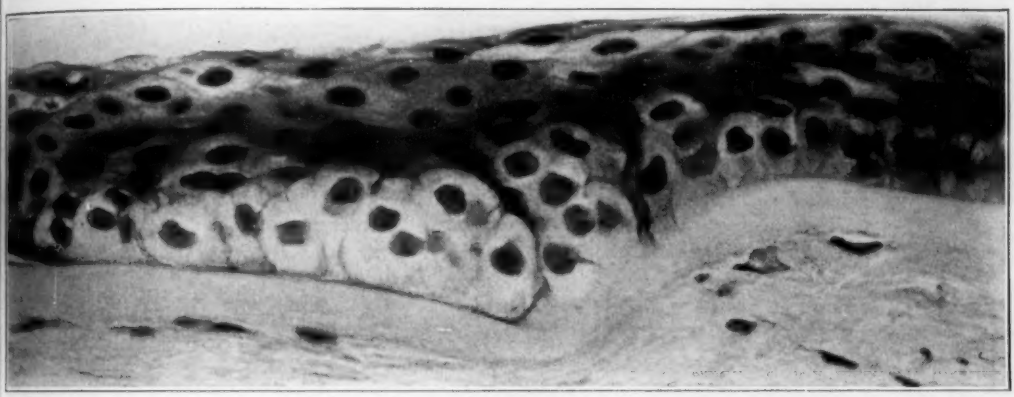


Fig. 12.—Recent injury to Bowman's membrane; × 515. Edematous basal cells have been pushed over to fill the epithelial defect. Mitotic figures are not yet present. Note the regular outer surface.

owing to an unsatisfactory restitution of their terminal nerve fibers. At times these successive erosions may result in epithelial cells producing filamentary projections from the corneal surface, a condition often spoken of as filamentary keratitis.

When the injury extends deeper, penetrating through Bowman's membrane, the loss of tissue is replaced in the same manner by epithelium. If the defect of the substantia propria is a small one, the epithelium proliferates from the margins and fills the defect. Beneath this primary plug the corneal corpuscles proliferate and form fibrous tissue, which gradually forces up and reduces in thickness the newly

19. Gifford, S.: Epithelial Dystrophy and Recurrent Erosion of the Cornea as Seen with the Slit-Lamp, Arch. Ophth. **54**:217, 1925.

formed epithelium, until it is equal in thickness to the epithelium covering the remainder of the cornea.[20] Bowman's membrane does not regenerate, so that the epithelium rests directly on the newly formed fibrous tissue. During this entire time the newly formed epithelium retains a level outer surface. Although Bowman's membrane does not regenerate, formations of this membrane are seen which are difficult to explain; among such are reduplications and localized thickenings. These are not artefacts, as has been held by some pathologists, but are actual

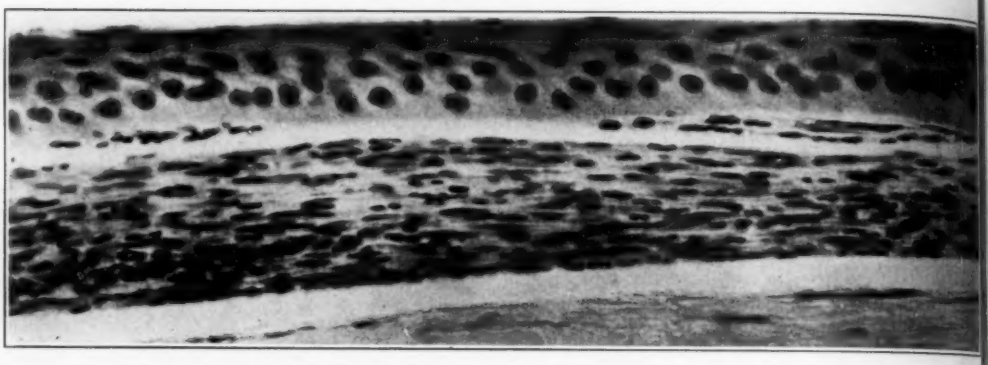


Fig. 13.—Pannus degenerativus with "reduplication of Bowman's membrane;" × 97. A layer of inflammatory fibrous tissue is interposed between two layers of Bowman's membrane, the lower of which is the original membrane.

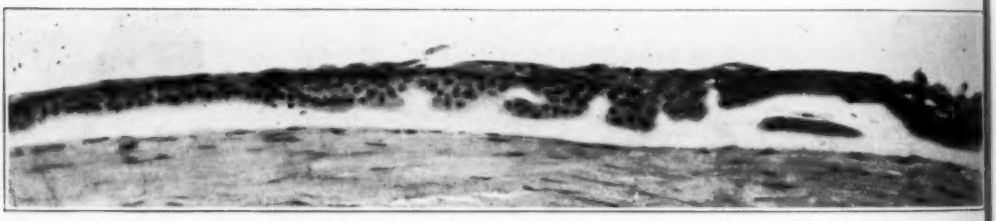


Fig. 14.—Irregular thickening of Bowman's membrane with peglike formation of epithelium; × 155.

formations of hyalin-like substance in sheets and masses. Since the origin of Bowman's membrane is shrouded in mystery, it is hazardous to venture an explanation for these formations. It is possible, however, that they are formed as an altered metabolic product of the corpuscles of the stroma.

In a perforating wound of the cornea uncomplicated by infection or prolapse of intraocular tissue, coaptation first occurs in the central area of the wound. The anterior and posterior margins of the wound

20. Fuchs, E.: On Keratitis, Tr. Ophth. Soc. U. Kingdom **22**:15, 1902.

gape, owing to the retraction of Bowman's and Descemet's membrane, by virtue of the elasticity of the latter, and the tension exerted on both membranes from their periphery. This produces a wedge-shaped gap anteriorly and posteriorly.[21] The anterior triangle becomes filled within twenty-four hours by a plug of epithelium extending into it from the sides and then proliferating. Later this plug undergoes a process of consolidation. The posterior triangle is usually wider than the anterior, for Descemet's membrane is more elastic and therefore retracts more than any other part of the cornea. The gap becomes filled with fibrinous coagulum and with endothelial cells, which form heaps at the edges and grow across to cover the posterior surface. This endothelial regeneration is a slower process than the epithelial regeneration, but small wounds are usually covered in three to four days. When the endothelium is again intact, any further filtration of aqueous into the wound ceases. The cut and rolled ends of Descemet's membrane never unite, but in the course of time a new hyaline layer may be formed which bridges the gap between them. This is formed by the activity of the endothelial cells, just as is the normal Descemet's membrane. Ultimately the new layer becomes as thick as the normal membrane, with whose curled edges it frequently fuses, giving the appearance of a splitting of the membrane.

Frequently the epithelium does not limit itself to forming a plug to fill up the anterior triangle of a perforating wound but grows down to line the channel through the depth of the cornea. It will also proliferate into the anterior chamber, where it will grow over the posterior surface of the cornea and over the iris, forming a cystlike structure in the chamber. At other times it will form the lining for a tortuous channel through the stroma, giving bizarre patterns when sections are studied. According to Corrado,[22] implantation of epithelium is not sufficient, but a delayed closure of the wound is essential. In the anterior chamber the epithelium forms a variable number of layers, at times even having a typical stratified formation. These epithelial ingrowths are most usually seen after a cataract section in which there has been a slow healing of the wound. Perera [23] expressed the belief that incarceration of iris and lens capsule in the wound is an important factor in epithelization of the anterior chamber and that hypotony favors its growth. He could not produce epithelization in rabbits merely by

21. Parsons, J. H.: The Pathology of the Eye, New York, J. P. Putnam's Sons, 1904.

22. Corrado, M.: Glaucoma secondario a penetrazione e proliferazione di epitelio in C. A. in occhio operato di cataratta, Ann. di ottal. e clin. ocul. **59:** 706, 1931.

23. Perera, C. A.: Epithelium in the Anterior Chamber of the Eye After Operation and Injury, Am. J. Ophth. **21:**605, 1938.

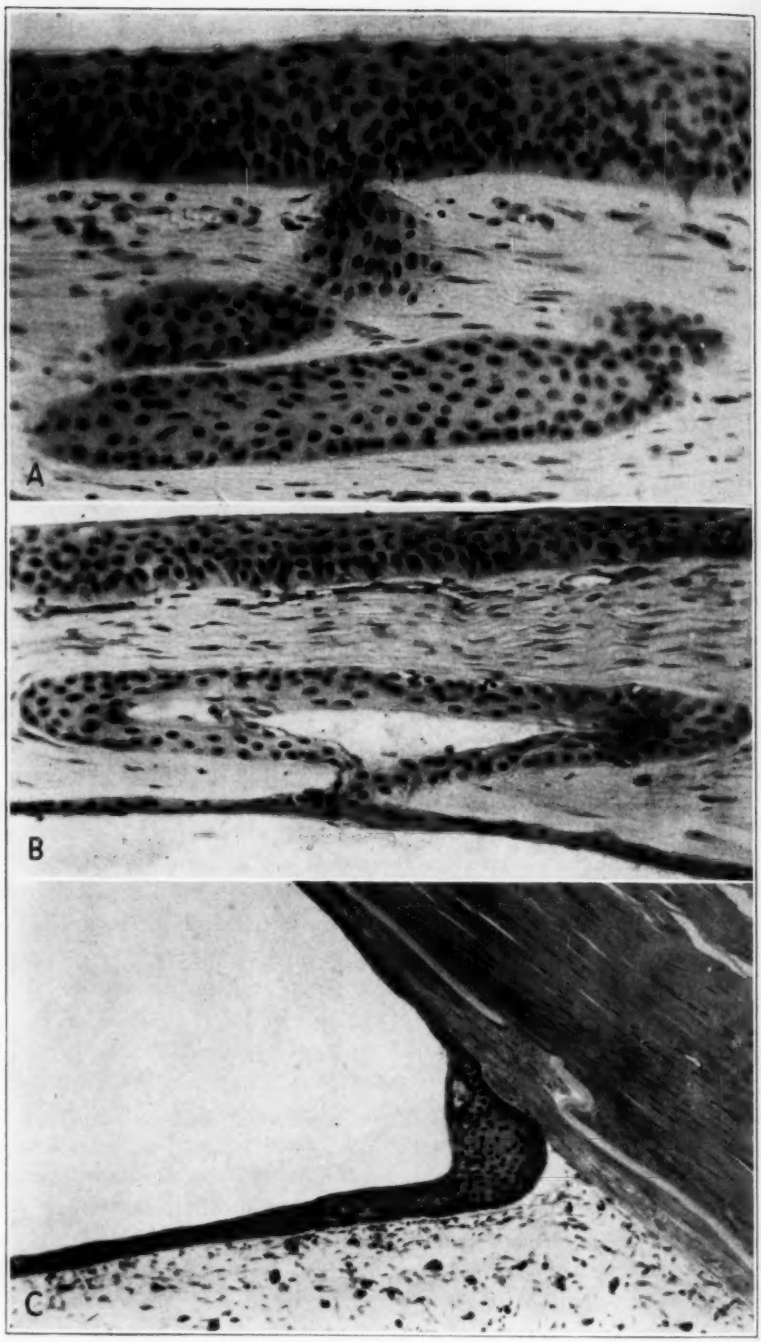


Fig. 15.—*A*, cordlike invasion of the stroma by epithelium; × 195. Note the defect in Bowman's membrane. *B*, epithelium has invaded and lined a channel through the stroma, opening into the anterior chamber and spreading over the posterior corneal surface; × 217. *C*, proliferation of the surface epithelium in the anterior chamber, lining the posterior corneal surface, angle of the anterior chamber and anterior surface of the iris; × 110. Note the break in Descemet's membrane.

implanting a corneal flap in the anterior chamber, for the epithelium always degenerated. The process may be as rapid as four days or may even occur after several years. Treatment with radium and roentgen rays has been used by Vail [24] and others, but results have not been uniformly good.

INFLAMMATION

Inflammation of the cornea cannot be classified satisfactorily on the basis of causation, but for the present purposes a division into nonpurulent and purulent inflammation is adequate. In the nonpurulent type both the epithelium and the endothelium show evidence of inflammation, depending on the virulence of the disturbance in the substantia propria. In both of these surface layers there occurs edema followed by desquamation, with regeneration on the subsidence of the inflammation. The epithelium also participates in numerous conjunctival inflammatory disturbances of a nonpurulent nature, such as phlyctenular keratitis, trachoma, vernal catarrh, pemphigus and chronic follicular conjunctivitis.

As has been mentioned previously, the intact epithelium offers an obstacle to the invasion of the cornea by all micro-organisms, with the possible exception of the gonococcus and the diphtheria bacillus. There are, however, many conditions which assist the entry of bacteria, the most common being minute abrasions resulting from corneal foreign bodies. Other factors, such as neuroparalytic disturbances, edema and keratomalacia, may aid by diminishing the resistance of the epithelium. At the beginning of these purulent inflammations, exfoliation of the epithelium occurs, but soon its regenerative powers prevail even if the inflammation persists. Bowman's membrane is usually destroyed with the epithelium, and there is a dense infiltration of the underlying stroma with pus cells. This necrotic stroma is then cast off, leaving a sloughing ulcer the margins and floor of which are infiltrated with pus cells. Even though the inflammation is still in its progressive stage, the epithelium begins to manifest its reparative activities in covering this bare tissue. Fuchs [20] has shown how it spreads over margins of the ulcer, penetrates the lamellar interspaces and may even cover the floor of the ulcer while it is still purulent, lying directly on pus and necrotic material. If the necrosis extends to Descemet's membrane, a keratocele or rupture may result. So long as Descemet's membrane remains intact, organisms cannot pass through it. It is, however, permeable to toxins, which diffuse into the anterior chamber and induce a chemotactic response of leukocytes and fibrin. This hypopyon is sterile, since no organisms have passed through the intact Descemet's membrane, and it may disappear

24. Vail, D.: Epithelial Downgrowth into Anterior Chamber Following Cataract Extraction: Arrest by Radium Treatment, Arch. Ophth. **15**:270 (Feb.) 1936.

almost as quickly as it occurred. With the regression of the infection, cicatrization of the cornea results. The repair of Bowman's and Descemet's membrane is the same as that described in wounds.

The endothelium undergoes degeneration during the course of such purulent inflammations. The cells become edematous, with a shrinking of the protoplasm and enlargement of the nucleus, followed by their vacuolation and desquamation. Edema, or "bedewing," of the endothelium also occurs in uveal inflammations, usually preceding precipita-

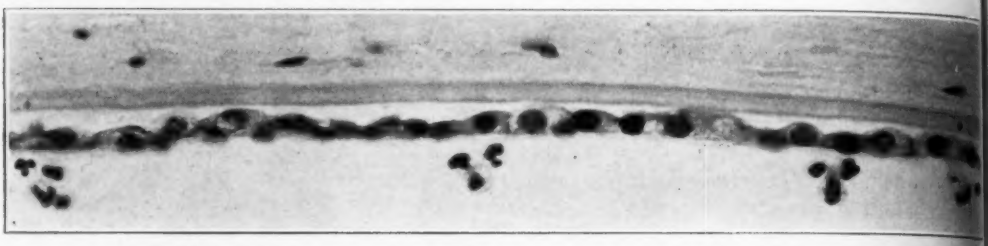


Fig. 16.—Edema and detachment of the endothelium; × 440. The leukocytes are clumped on the posterior corneal surface.

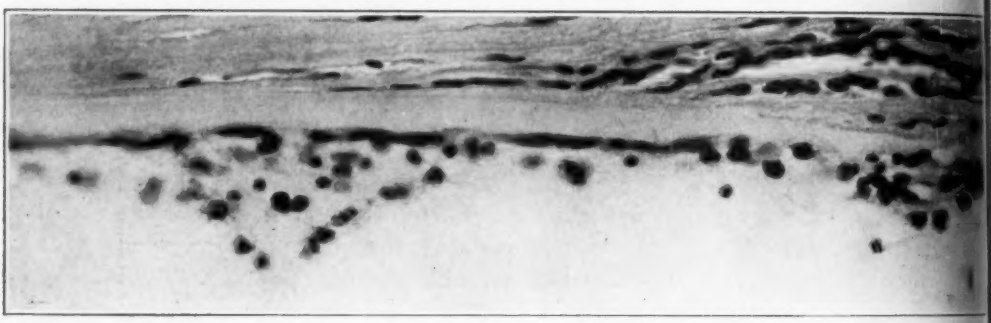


Fig. 17.—Clumping of the mononuclear cells and plastic exudate on the posterior corneal surface, forming "mutton-fat" deposits; × 213.

tion of cells on the posterior corneal surface. The cellular clumps may be of various sizes and distribution. In the cases of acute inflammation they may be made up of leukocytes, together with intracellular and extracellular pigment granules and fibrin. Those in cases of long-standing involvement, especially of tuberculosis, are conglomerate masses of mononuclear cells and plastic substance, forming the "mutton-fat" deposits. These deposits tend to subside with the inflammation, some disappearing rapidly, while others persist for years.

A posterior corneal abscess can occur either without hypopyon or with hypopyon ulcer when the posterior corneal stroma shows little

evidence of infiltration (Samuels [25]). This type of abscess may lie between the stroma and Descemet's membrane, or even between the layers of the fragmented Descemet's membrane. It is difficult to judge whether such posterior corneal abscesses result from leukocytes migrating from the peripheral vessels and attacking Descemet's membrane from the front, or whether they are derived from the hypopyon by destoying Descemet's membrane from behind. It is likely that both mechanisms may operate.

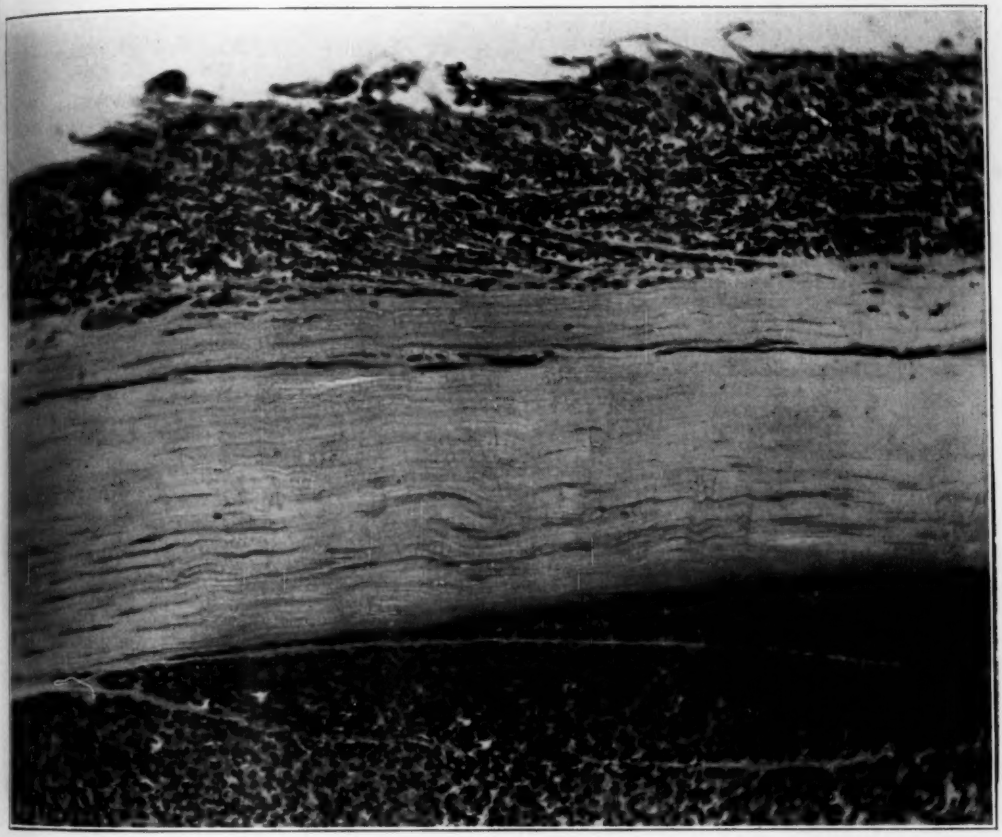


Fig. 18.—Splitting of Descemet's membrane by a posterior corneal abscess; × 282. There is an infected corneal ulcer, but stroma between it and the hypopyon shows no infiltration of leukocytes. Descemet's membrane appears to have been attacked from the back and fragmented.

Lieut. Col. J. E. Ash and Mrs. Helenor C. Wilder of the Army Medical Museum assisted in the preparation of this material.

25. Samuels, B.: Methods of Formation of Posterior Abscess in Ulcus Serpens, Arch. Ophth. **7**:31 (Jan.) 1932.

News and Notes

EDITED BY W. L. BENEDICT

SOCIETY NEWS

Pan-American Congress of Ophthalmology.—The first Pan-American Congress of Ophthalmology will meet in Cleveland, Oct. 11 and 12, 1940, under the sponsorship of the American Academy of Ophthalmology and Otolaryngology, a society of more than 2,500 specialists of the United States.

The first event of the congress will be a joint banquet with the academy on Wednesday evening, October 9, at which Dr. Frank Brawley, Chicago, president of the academy, will preside. On Thursday afternoon, October 10, the official delegates appointed by the various governments will meet with representatives of ophthalmologic societies to draw up a constitution and make plans for future meetings.

The scientific program will occupy two days, Friday and Saturday, October 11 and 12. An equal number of papers will be contributed by speakers from the Latin-American countries and by those from the United States. Papers in Spanish and Portuguese will be discussed by English-speaking physicians and those in English by Latin-American speakers. Slides giving a résumé of each paper are to be shown on a screen in the two languages other than the one in which the paper is written.

Among those from South American countries who will appear on the program will be: Dr. Pereira Gomes, chief of an eye clinic at the General Hospital, São Paulo, Brazil; Dr. Cesario de Andrade, professor of ophthalmology, Faculty of Medicine, Surgery and Pharmacy, Bahia, Brazil; Dr. A. Vasquez Barriere, professor of ophthalmology, University of Montevideo Faculty of Medicine, Montevideo, Uruguay; Dr. Carlos Charlin, professor of ophthalmology, University of Santiago, Chile, and Dr. Santiago Barrenechea, assistant professor of ophthalmology, University of Santiago, Chile.

In addition, there will be Dr. Arturo Quevedo, Guatemala City; Tomas R. Yanes, Habana, Cuba, editor of the *Revista cubana de oto-neuro-oftalmiatría;* Rafael Silva, Mexico City, for many years secretary of the Sociedad Mexicana de Oftalmología y Otorrinolaringología; Manuel U. Troncoso, formerly of Mexico and now of New York, and Manuel Marquez y Rodriguez, formerly a prominent ophthalmologist and teacher in Madrid, now living in Mexico City.

Among those who will discuss papers presented in English will be: Drs. Horacio Ferrer, Habana, Cuba; Mendonca de Barros and Feliciano Penido Burnier, São Paulo, Brazil; Heitor Marback, Bahia, Brazil, and Aniceto Solares, La Paz, Bolivia.

English-speaking physicians who will present papers will include: Dr. William L. Benedict, the Mayo Clinic, Rochester, Minn.; Dr. Derrick T. Vail, professor of ophthalmology, University of Cincinnati, Cincinnati; Dr. S. Hanford McKee, professor of ophthalmology, McGill

University Faculty of Medicine, Montreal, Canada; Dr. John O. McReynolds, Dallas, Texas; Dr. Samuel Rodman Irvine, Los Angeles; Dr. Alan Woods, acting professor of ophthalmology, Johns Hopkins University School of Medicine, Baltimore; Dr. Sanford Gifford, professor of ophthalmology, Northwestern University Medical School, Chicago, and Dr. Arthur J. Bedell, Albany, New York.

The committee of the American Academy of Ophthalmology and Otolaryngology which is arranging the Pan-American Congress is made up of Drs. Harry S. Gradle, Chicago; Conrad Berens, New York, and Moacyr E. Alvaro, São Paulo, Brazil.

New Society.—Sixty specialists, meeting in Tampa, Fla., on April 30, 1940, formed the Florida Society of Ophthalmology and Otolaryngology, as a permanent organization. Dr. H. Marshall Taylor, of Jacksonville, was elected president; Dr. S. B. Forbes, of Tampa, vice president, and Dr. Carl E. Dunaway, of Miami, secretary-treasurer.

At a scientific assembly at the Hillsboro Hotel, Dr. Bascom H. Palmer, of Miami, discussed devitalized teeth as a factor in diseases of the eye, and Dr. H. Marshall Taylor, of Jacksonville, lectured and showed motion pictures on the otorhinologic hygiene of swimming. Dr. Shaler Richardson, of Jacksonville, discussed retinal detachment and Dr. M. A. Lischkoff, of Pensacola, described the surgical treatment of deafness.

Leslie Dana Gold Medal.—The Leslie Dana Gold Medal, awarded annually by the St. Louis Society for the Blind for outstanding achievements in the prevention of blindness and the conservation of vision, was conferred on John M. Glenn, a director of the National Society for the Prevention of Blindness. The presentation was made at the luncheon of the Association for Research in Ophthalmology, at the Biltmore Hotel in New York, Tuesday, June 11, 1940.

Treacher Collins Prize Essay.—Under the title of the Treacher Collins Prize Essay, the Council of the Ophthalmological Society of the United Kingdom has instituted a prize of 100 pounds, awarded triennially, for the best essay submitted on a subject selected by the council. The prize shall be open to qualified medical practitioners of any nationality, and the essay shall be written in the English language. The subject for the second award of the prize is "Allergic Affections of the Eye and Its Adnexa."

The closing date for sending in essays for the second award is Dec. 31, 1941. Essays should be submitted to the Honorary Secretary, Ophthalmological Society of the United Kingdom, 5 Racquet Court, Fleet Street, E.C.4, from whom also any further particulars can be obtained. No name should be on any essay, but a distinguishing pseudonym or quotation, which should also be on a sealed envelope containing the candidate's name and address. The envelope should accompany the essay.

GENERAL NEWS

Verhoeff Testimonial Dinner.—One hundred and seventy-five friends and admirers gathered at a testimonial dinner held on June 2 at the Homestead, Hot Springs, Va., to honor their guest, Dr. Frederick H. Verhoeff, and to pay tribute to his achievements in ophthalmology during the past forty years. Under the skilful direction of Dr. E. V. L. Brown, toastmaster, expressions of respect covering the human and the professional qualities of the guest of honor were voiced by Drs. Jonas Friedenwald, Edwin Neher, Hans Barkan, Phinizy Calhoun, Hugo Riemer, Allen Greenwood and Herbert Waite. A clever cartoon enlivened the menu card. The gracious response of Dr. Verhoeff climaxed an occasion which will remain memorable to all those who attended the dinner.

Course for Orthoptic Technicians.—The staff of the Illinois Eye and Ear Infirmary in Chicago announces a six month course for orthoptic technicians, to start on Oct. 1, 1940. The work will follow closely the recommendations of the orthoptic council. Applications should be accompanied by a letter of recommendation from an ophthalmologist and be sent to the dean of instruction, the Illinois Eye and Ear Infirmary, 904 West Adams Street, Chicago.

PERSONAL

Retirement of Dr. Verhoeff.—A life of distinguished service will be brought to completion through the academic retirement at the close of the current year of Dr. Frederick H. Verhoeff as professor of ophthalmic research at Harvard University and as director of the Howe Laboratory of Ophthalmology. For forty years Dr. Verhoeff has been in active service at the Massachusetts Eye and Ear Infirmary in the capacity of pathologist, ophthalmic surgeon and consulting chief of staff. For sixteen years he has served as professor of ophthalmic research at Harvard University, and for nine years he has directed the research work of the Howe Laboratory of Ophthalmology.

Appointment of Dr. D. B. Kirby.—Dr. Daniel B. Kirby was appointed professor of ophthalmology in the College of Medicine of New York University and director of the ophthalmic service of the Bellevue Hospital on June 1, 1940. He succeeds Dr. Webb W. Weeks in the posts formerly held by Drs. J. E. Weeks and J. M. Wheeler.

Obituaries

MARIUS TSCHERNING, M.D.
1854-1939

Marius Tscherning died in Copenhagen, Denmark, on Sept. 9, 1939, at the age of 85 years. He was born at Oestrup, Denmark, and graduated in medicine from the University of Copenhagen in 1882. Postgraduate study brought him to Paris, France, where he became an associate of Javal, whom he succeeded as director of laboratory for physiologic optics at the Sorbonne. Here he instructed ophthalmologists from all parts of the world. Tscherning was called in 1910 to succeed Bjerrum as professor of ophthalmology at the University of Copenhagen, and he in turn was succeeded by Lundsgaard in 1925.

One of Tscherning's earliest investigations was made in support of the role played by near work in the development of myopia, although myopia of high degree occurred without regard to near work or social position. His name, however, is better known in connection with the theory of accommodation. He was a persistent antagonist of the Helmholtz hypothesis, though his views have never met with general acceptance.

He made investigations on the law of Listing, on the images of Purkinje, on correcting glasses for oblique gaze and on the calculation of orthoscopic glasses. He attempted to standardize the methods of examining the light sense and light differential sensibility, and his photometric glasses gave rise to a number of investigations on night blindness, difficulties in adaptation and hypovitaminosis. He also paid a great deal of attention to the study of color vision, and his color equations obtained with his spectrophotometer have been of value.

He edited "Optique physiologique" and contributed the chapter on "Dioptrique oculaire" in the "Encyclopédie francaise d'ophtalmologie."

This short outline shows the industry and enthusiasm with which Tscherning devoted his life to physiologic optics; his kindness and generosity will always be remembered by those who worked in his laboratory.

RICHARD JAMES LYTHGOE
1896-1940

Dr. Richard J. Lythgoe died on Feb. 28, 1940. Born in 1896, he was educated at Trinity College, Cambridge, England, and at University College, London, England. In 1924 he entered the department of physiology in the University College, where he began the line of investigations which occupied his energies for the rest of his life. His postgraduate life was devoted to research work, and he held the Beit Memorial Research Fellowships from 1929 to 1933 and was an investigator under the Medical Research Council and by grants from the Rockefeller Foundation. He was also a reader in the physiology of the special senses at the University College and almost every year has given a course of advanced lectures on the physiology of vision. He was one of the few men who devoted himself to investigating physiology of the special senses.

In 1931 he married Dr. Katherine Tansley, who had been a student in his course of advanced instruction in the physiology of the special senses, and who then became a collaborator in investigations on adaptation of the eye in relation to the critical frequency of flicker. Dr. Lythgoe also made studies on visual acuity, visual purple, night blindness and vitamin A.

A life of promise and that of a talented scientist has come to a premature close; deepest sympathy is extended to his widow and three children. An obituary of Dr. Lythgoe appeared in the *British Medical Journal* for April 13, 1940, page 640.

ARNOLD KNAPP.

Correspondence

CORNEOEPISCLERAL SUTURE IN CATARACT EXTRACTION

To the Editor:—A review of the results of 100 consecutive cataract operations in which a corneoepiscleral suture was a part of the routine technic indicates results similar to those reported by Dr. John M. McLean in the March 1940 issue of the ARCHIVES, page 554. Our series of cases, covering the period from January 1939 to January 1940, is now supplemented by a like number, indicating the many advantages from the standpoint of the patient, from the standpoint of hospitalization and from the standpoint of the surgeon's comparative freedom from worry with regard to postoperative complications. As statistical analysis will not lend itself to a critical interpretation in a communication such as this, a general summary of our impressions follows:

1. There is a reduction of two or more days in the length of the patient's stay in the hospital.

2. Except for accidental trauma by the patient, there is almost complete elimination of such serious postoperative complications as prolapse of the iris, choroidal hemorrhage, hemorrhage in the anterior chamber and iridocyclitis.

3. There is complete elimination of such general complicating factors as backache, tympanites, mental confusion, gastrointestinal disorders and urinary disturbances.

4. By getting the patient out of bed from the first to the fifth day and letting him use the eye that was not operated on on the third day, there is established a happier mental attitude, as the patient is most often an aged person who is accustomed to and desires to attend to his personal toilet, to feed himself and to sit upright in a chair.

5. Obese persons, the very aged and those with heart disease or orthopedic deformities are permitted out of bed the first day of the operation.

6. The need for capsulotomy in extracapsular extraction is reduced to a small proportion.

7. The toilet of the operative wound may be done slowly, carefully and without fear of loss of vitreous.

8. Corneal astigmatism, in most instances, is less than in cases in which sutures are not used.

Our technic, however, differs from that of McLean. We have adopted as a routine measure the use of a corneoepiscleral suture which is certainly not new. We are using, however, an 00000000 silk suture with a very fine atraumatic needle, manufactured by Davis and Geck.

We are happy to corroborate and to fortify the experience of McLean in the advantages of corneal sutures.

LOUIS LEHRFELD, M.D.,
Attending Surgeon, Wills Hospital.

E. J. DONNELLY, M.D.,
Senior Assistant Surgeon, Wills Hospital, Philadelphia.

Questions and Answers

BASE-IN PRISMS IN BIFOCAL LENSES FOR PRESBYOPES

To the Editor.—Will you please help me to a better understanding of a matter by answering the following question: What is the best known procedure for determining the need and strength of base-in prisms in the segments only of bifocal lenses intended for presbyopes? The question, of course, pertains to the measuring of convergence efficiency at the reading distance and its treatment with prisms. D. D. S.

Answer.—Prisms bases in should be used for close work only in cases in which after all other means have been tried they offer the only possible chance of relief. In each case extreme care should be taken in the refraction, so that there is no doubt in regard to the accuracy of the correcting lenses. Reading glasses must be of such strength that the working distance is kept as far away as possible. At best only 2 or 3 prism diopters can be well tolerated. Experience has shown that before the prisms are permanently ground in the segments of bifocal lenses intended for presbyopes it is well to try their effect in a "hook front." In this way it will be found whether or not they give sufficient relief to make reading comfortable in the cases in which they are indicated.

NUMMULAR KERATITIS

To the Editor.—Have any definite steps been taken in the direction of effective therapy for nummular keratitis? L. W. O.

Answer.—In Dimmer's keratitis nummularis the presence of superficial corneal vascularization from the vessels of the limbus, the similarity of the lesion to superficial punctate keratitis at the onset and its usual unilateral occurrence exclude the disease from the classification of corneal dystrophies.

In the acute stage, which is often accompanied by mild iritis, the use of atropine is necessary. In the very protracted later course a circumscribed central grouping of depressions without ulceration is followed by faint, round, mottled disks at the level of Bowman's membrane. This final characteristic may be the first indication allowing of a definite diagnosis of Dimmer's keratitis nummularis.

Salzmann observed this condition in the fall among a large series of harvesters. In 1933 Aust described a case. A. Fuchs reported similar corneal conditions among the workers in the rice fields in Ceylon. Lindner has agreed with these observers that the condition may be justly ascribed to a fungus. The treatment is symptomatic and should include the use of fungus-destroying antiseptics.

Abstracts from Current Literature

EDITED BY DR. WILLIAM ZENTMAYER

Anatomy and Embryology

DEVELOPMENT OF THE OLIGODENDROGLIA, THE ASTROGLIA AND THE CONNECTIVE TISSUE OF THE OPTIC NERVE DURING FETAL LIFE. A. LUNDBERG, Acta ophth. **17**: 259, 1939.

The author first briefly reviews the early embryonic development of the glia and mesoderm in the optic nerve and chiasm. He describes a series of histologic observations of his own, made at various stages of fetal growth. His conclusions are, in part, as follows: The ectodermal cells of the optic stalk serve to form the neuroglia. These cells remain undifferentiated and irregularly scattered until after the penetration of the stalk by the growing optic nerve fibers. At about the 5 cm. stage it is possible to distinguish two types of glial cells, one resembling astrocytes and the other oligodendrocytes. At this stage begins the invasion of mesodermal elements, capillaries and connective tissue, arising from the sheath of the optic nerve. At the 9 cm. stage connective tissue strands from the optic nerve sheath have formed partitions in the substance of the nerve. In this framework capillaries are evident. The neuroglia are more clearly differentiated. At the 17 cm. stage the oligodendrocytes have come to occupy chiefly the peripheral portions of the various bundles of nerve fibers, while the astrocytes, now with two or three protoplasmic extensions, are in the middle of the bundles. They look about as they do in an infant at birth.

O. P. PERKINS.

Conjunctiva

PATHOLOGIC ANATOMY OF CONJUNCTIVAL XEROSIS. R. ARGAUD and R. BERGES, Arch. d'opht. **2**: 97 (Feb.) 1938.

The authors first describe 2 cases in which Bitot spots were excised and studied histologically. They next review what has appeared in the literature in regard to the histologic appearance of these spots. The inadequacy of previous histologic reports has prompted the present report, which includes a number of photomicrographs. In summing up the histologic picture described, they say that the basic anatomic change lies in the generative layer of the conjunctival epithelium.

S. B. MARLOW.

APPLICATION OF THE CREDÉ METHOD IN ITALY. L. MAGGIORE, Ann. di ottal. e clin. ocul. **67**: 401 (June) 1939.

For various reasons it was not until 1928 that Credé prophylaxis was required by law in Italy for infants whose birth was attended by midwives. Washing the lids and the surrounding skin with potassium permanganate in a dilution of 1 : 4,000 was required for all infants, while only when the mother showed signs suggestive of vaginal infections was the use of a 1 per cent solution of silver nitrate required. The author sent a questionnaire to heads of clinics and to obstetricians

requesting information as to the type of prophylaxis used and reports of accidents as a result of the drug employed and of failures of the treatment to prevent infection. Thirty-four obstetricians replied. Twenty-four used silver nitrate and 8 solutions of silver protein varying from 3 to 10 per cent. Fifteen, while employing silver nitrate, believed that a milder form of prophylaxis might be preferable as involving less risk of accidents due to faulty technic. Twenty-two had observed signs of conjunctival irritation as a result of the drug but no serious results. Ten had observed no irritative effects. Nine had not seen any cases in which prophylaxis failed to prevent infection. Twenty-three had seen occasional cases of ophthalmia neonatorum after prophylaxis, but they attributed these to insufficient care in instillation of the drops. All but 3 agreed that prophylaxis should be obligatory, and almost all insisted that it should be employed only by the physician or by a nurse of proved ability. The 3 who dissented believed that prophylaxis might be omitted only when the integrity of the birth canal was certain. Answers from heads of the principal ophthalmic clinics agreed in general with those of obstetricians. Two thirds advocated a substitute for silver nitrate, usually silver protein in a 3 to 10 per cent solution. A few serious results from prophylaxis were reported, all as a result of errors in dosage. Most of the heads of clinics agreed that the use of a 1 per cent solution of silver nitrate involved no danger to the eyes. They also agreed as to the advisability of compulsory prophylaxis. S. R. GIFFORD.

Comparative Ophthalmology

COMPARATIVE HISTOPHYSIOLOGY OF THE FOVEA IN VERTEBRATES. L. VERRIER, Bull. Soc. d'opht. de Paris **51**: 99 (Feb.) 1939.

The modalities of central and of peripheral vision are attributed to a large degree to the anatomic and histochemical characteristics (composition and properties of the pigments) of the different regions of the retina.

In Parinaud's classic volume on vision and in von Kries's interesting investigations the dual theory is advanced. Researches on vertebrate eyes should reveal some interesting facts concerning such a theory. Verrier has studied about 250 vertebrate eyes. Included are members of the order of fish, frogs and toads, reptiles, birds and mammals.

The following conclusions are presented: The foveas of this series of vertebrates present great similarities to the extrafoveal regions.

1. With regard to the form of the visual cells, when the peripheral region possesses typical rods it is apparent that they approach the foveal cones in nature.

2. The reparation of the visual purple is very comparable in the foveal and the extrafoveal region. Microanalytic study will doubtlessly indicate later to what extent this comparison is possible. The fovea does not seem to be clearly distinguished from the adjacent regions (1) because of the disposition of the melanin of the pigmented epithelium in its level (fringes longer, sharper and richer in melanin) and the addition of macular pigment and (2) because of the disposition and richness of the elementary receptors and conductors. L. L. MAYER.

Cornea and Sclera

RESULTS OF VITAMIN-D COMPLEX TREATMENT OF KERATOCONUS. A. A. KNAPP, Am. J. Ophth. **22:** 289 (March) 1939.

Following the use of viosterol and calcium in cases of keratoconus, Knapp draws the following conclusions:

"From the foregoing data, it may be concluded that the vitamin-D complex has a definite place in the therapy of keratoconus. Further research will determine its proper position in the therapeusis of this condition."

W. S. REESE.

UNUSUAL DEGENERATION OF THE CORNEA: REPORT OF A CASE. M. POVOLOTSKAYA-BURSHTEYN, Vestnik oftal. **13:** 258, 1938.

A child aged 10 years, suffering from a progressive, degenerative process of the left cornea, has been observed for five years. The vision gradually decreased from 0.6 to 0.04. The conjunctiva of that eye was thickened and had a number of follicles. A grayish white plaque was seen in the superficial layers of the cornea with focal and with slit lamp examination. The number of these opacities increased during the period of observation, the cornea becoming diffusely opaque. There was also some vascularization of the cornea. There were frequent exacerbations of the process, with desquamation of the epithelium of the cornea. Opacities and newly formed blood vessels gradually developed on the cornea of the other eye without any inflammatory symptoms. Parallel with it, the conjunctiva became thickened and follicles formed. The child was anemic, but general and local therapy gave no striking results.

O. S. SITCHEVSKA.

Experimental Pathology

THE ROLE OF THE CERVICAL SYMPATHETIC GANGLIA AND MÜLLER'S ORBITAL MUSCLE IN EXPERIMENTAL EXOPHTHALMOS. G. K. SMELSER, Am. J. Ophth. **22:** 1201 (Nov.) 1939.

Smelser compares the orbits of man and experimental animals in respect to Müller's muscle and its effectiveness in producing exophthalmos. Following experiments on guinea pigs, he draws the following conclusions:

"1. The hypertrophy and pathological modification of the retrobulbar tissue found in exophthalmos produced by injection of anterior-pituitary extract into thyroidectomized guinea pigs is independent of Müller's orbital muscle.

"2. These changes are unaffected by unilateral or bilateral extirpation of the cervical sympathetic ganglia.

"3. The ptosis created by sectioning the cervical sympathetic ganglia or removing Müller's muscle decreases the apparent degree of exophthalmos.

"4. Exophthalmos produced as described, and judged post mortem after removal of the skin and lids, is not dependent either upon Müller's orbital muscle or sympathetic innervation through the cervical ganglia.

"5. Orbital decompression, as achieved in these experiments, does not relieve the condition of the orbital tissues, but slightly decreases the degree of proptosis."

W. S. Reese.

Importance of Perforation of the Globe in the Operative Technic for Detachment of the Retina: Participation of the Episcleral Connective Tissue in the Cure. L. Weekers, Arch. d'opht. **2**: 193 (March) 1938.

Weekers reviews the work which has been done to show that in the healing of wounds of the sclera episcleral tissue plays an important part. In this presentation he reports some experiments done on rabbits' eyes which have been punctured by a fine sharp knife and then after varying intervals examined under the microscope. In the photomicrographs presented the invasion of the wound by episcleral tissue to hold the retina down at the point of perforation is demonstrated. To show whether or not this same process takes place in the human eye, he has punctured the sclerotica in eyes otherwise diseased in which enucleation is to be done, and in all these instances the same invasion of the episclera was demonstrated. Diathermic needles were used, and the instance cited seem to indicate that if too much current is used the necrosis of the sclera and choroid which results tends to block the wound and hinder the episcleral invasion and hence vitiates to some extent the effects of the operation. He believes that the episcleral adhesions form much stronger points of attachment than do the wider areas of coagulation resulting from surface diathermy.

S. B. Marlow.

General Diseases

Familial Hemorrhagic Angiomatosis and Its Ocular Complications. J. François, Arch. d'opht. **2**: 425 (May) 1938.

François briefly describes the picture of familial hemorrhagic angiomatosis. The condition was first described by Rendu in 1896 and subsequently individualized in 1901 by Osler. Several hundred cases have appeared in about 50 families in Europe and in America. The condition has been found in only 4 families in Belgium, the case reported in this article representing the fourth family. The patient was a woman aged 74, whose chief symptom was profuse bleeding from the eye. The author feels that the interest in this case centers on the difference in the type of conjunctival lesions as compared to those of the skin in the first place and on the absence of ocular complications in the second place. A rather complete bibliography accompanies the article.

S. B. Marlow.

Besnier-Boeck Disease or Benign Lymphogranulomatosis of Schaumann with Involvement of the Eye: Report of a Case. H. Coppez and B. Dujardin, Arch. d'opht. **2**: 497 (June) 1938.

Coppez and Dujardin report in detail a case of Boeck's disease in which both eyes were involved with iridochoroiditis. They refer to the syndrome described by Herrfordt as a uveoparotid fever. The ocular

complications in this disease are of two sorts. The first type of complications are conjunctival, the lesions simulating Mikulicz' disease. The tarsal conjunctiva contains numerous yellowish translucent slightly elevated follicles, sometimes confluent. The second type consists of involvement of the iris and ciliary body, the iritis often presenting the picture of tuberculosis. It is a manifestation of a localization of the general disease of the reticuloendothelial system. Probably Herrfordt's disease and also Mikulicz' disease are of the same nature, and the authors suggest that it is not impossible that some conditions thought to be tuberculous are really this disease.

S. B. MARLOW.

VASOPATHY AND THE EYE. K. LISCH, Klin. Monatsbl. f. Augenh. **102:** 228 (Feb.) 1939.

The author refers to a paper in preparation, in which Dr. Breig, of the neurologic clinic at Munich, discusses vasopathy. Breig shows that the collective term of vasopathy includes Buerger's disease, several stages of vasoneurosis, Raynaud's gangrene and some cutaneous diseases, such as sclerodactylia and so-called Osler's disease, Lisch examined the eyes of 35 of Breig's patients with vasopathy who presented Quincke's edema, migraine and vasomotor angina pectoris in addition to the aforementioned conditions. Microscopic examination showed pathologic changes of the capillaries in each case and hemorrhages in the nail grooves in 51 per cent of the cases. Periphlebitis of the retina was absent in all cases. The presence of microscopic changes in the capillaries is not indicative of similar changes in the eyes or in other organs. Hardly any patient examined showed entirely normal capillaries. Vasopathy, or Buerger's disease, in Lisch's opinion was not as frequently the cause of retinal periphlebitis as was claimed by Marchesani.

The latter, on the other hand, proved that vasopathy may cause changes of the choroidal vessels and hemorrhages in the vitreous.

K. L. STOLL.

Glaucoma

MECHOLYL AND PROSTIGMINE IN THE TREATMENT OF GLAUCOMA. S. T. CLARKE, Am. J. Ophth. **22:** 249 (March) 1939.

Clarke briefly discusses miotics, epinephrine compounds and acetylcholine, mecholyl and prostigmine. He tabulates the results with the last two drugs in the treatment of glaucoma. He makes the following conclusions:

"1. In this short series, it is interesting to note that in six of the eight cases listed as failures there was subsequent trial of intensive anti-glaucomatous therapy using other drugs. In no case was the status of the patient improved and in four cases it became definitely worse.

"2. Of the 61 patients in this series under routine treatment with other anti-glaucomatous drugs when first seen, 41 were using pilocarpine and eserine, and 10 were using epinephrine compounds.

"3. Twelve of these patients had previously had intensive pilocarpine and eserine treatment without success before being treated with mecholyl or prostigmine, and in 10 of these the tension was brought to normal.

"4. Three patients had had intensive adrenalin-borate treatment before being seen, and two of these were brought to normal.

"From the results presented, it would appear that mecholyl and prostigmine may prove of considerable value in the treatment of glaucoma, especially in the acute and subacute stages."

W. S. REESE.

GLAUCOMA AND HEPATOPATHY. H. SCHMELZER, Klin. Monatsbl. f. Augenh. **102**: 231 (Feb.) 1939.

Schmelzer made systematic examinations of the metabolism of 55 patients with primary glaucoma and of 45 persons of corresponding age with normal intraocular tension. These examinations included tests for bilirubin, cholesterol, blood sugar, indican and uric acid in the blood serum. Tests for xanthoprotein of the serum and urinalysis were added. The food allowed these patients is described. Schmelzer concludes that the majority of patients with glaucoma suffer from disturbances of the liver. Proper nourishment, therefore, should beneficially influence the glaucoma by improving the general physical condition. The author recommends the inclusion of liver in the diet, aside from local ocular treatment and other therapeutic means.

K. L. STOLL.

BUPHTHALMOS OF THE LEFT EYE WITH COLLATERAL HEMIHYPERTROPHY OF THE FACE. L. STEIN, Klin. Monatsbl. f. Augenh. **102**: 541 (April) 1939.

A boy aged 8 years showed buphthalmos of the left eye when 2 years old. The left side of the face of this otherwise healthy child was greatly enlarged. A roentgenogram revealed corresponding differences of the bones of both sides of the skull. The congenital giantism of the face was due to unequal development on the basis of unequal development of the blood vessels, or trophoneurotic disturbances. The causation of this phenomenon is unknown. It appears in association with tumors, such as naevus flammeus, angiomas or lipomas.

K. L. STOLL.

Injuries

FOREIGN BODY TOLERATED IN THE EYE FOR TWENTY-NINE YEARS. E. J. Y. TROMEUR, Arch. d'opht. **2**: 124 (Feb.) 1938.

After pointing out that foreign bodies are of two kinds, those that do not produce a reaction or are indifferent and those which produce a reaction or are active, and that there are certain parts of the eye which tolerate foreign bodies badly whereas others tolerate them well, Tromeur describes in detail a case in which an intraocular foreign body was diagnosed in 1907 and the eye finally removed as the result of recurrent iridocyclitis with sympathetic irritation in 1936. As the result of the observations in this case, the author brings out the importance of an exact diagnosis, especially in cases of wounds of the cornea. Only a most complete examination will reveal the true condition at times. If the first examination in the case had not been made in detail and had not

been complete when the patient was first seen, it would have been difficult to attribute the iridocyclitis which occurred twenty-nine years afterward to the original injury. The importance of this from the point of view of compensation is emphasized.

S. B. MARLOW.

Lens

LENTICULAR METABOLISM IN RELATION TO CATARACT. C. A. VEASEY JR., Northwest Med. **38:** 97 (March) 1939.

Veasey discusses lenticular metabolism in relation to cataract and gives the following summary of the paper:

"This rather rambling resume has been presented in order to focus our attention on the experimental work which is going forward in an attempt to elucidate the etiology of nutritional cataract, and although a good deal of it is rather remote from clinical application, it may become important in the nonsurgical treatment of lenticular opacities."

W. ZENTMAYER.

THE CARBOHYDRATE METABOLISM OF THE ISOLATED LENS. R. WEEKERS, Compt. rend. Soc. de biol. **132:** 36, 1939.

The isolated rabbit lens, maintained in the apparatus of Bakker, when irrigated with Ringer's or Tyrode's solution begins to cloud by the second or third day. The addition of dextrose in a concentration of 1:1,000 definitely prolongs the transparency of the lens, so that clouding does not commence till the fifth or sixth day. No such favorable effect ensues when levulose or galactose is substituted.

J. E. LEBENSOHN.

CONGENITAL CATARACT WITH FORMATION OF CRYSTALS: REPORT OF A CASE. K. OBERHOFF, Klin. Monatsbl. f. Augenh. **102:** 238 (Feb.) 1939.

A man, aged 29, had had defective vision since early childhood. His father and two brothers had normal eyes and vision. The mother was dead; one sister, who died of tuberculosis at the age of 17, and a younger sister, aged 12, had "glistening" opacities in the lenses. The patient's lenses contained fine amorphous opacities of a grayish white hue and shaped like cones or buttons. These formations were scattered all over the cortex, except its equatorial strata; they presented polygonal or rhomboid form and were clear and refracting. Similar formations were described by a small number of authors. These bilateral, congenital and dominantly hereditary opacities have no relation to the anatomic structure of the lens. The lesion of the lens appears to have begun at an early fetal stage and continued for a considerable period after birth. This form of cataract is related to the coral-shaped type described by Gunn and Vogt's spear-shaped cataract.

K. L. STOLL.

Ocular Muscles

OPERATIVE THERAPY FOR ISOLATED BILATERAL PARESIS OF THE TROCHLEAR MUSCLE: REPORT OF CASES. P. A. JAENSCH, Klin. Monatsbl. f. Augenh. **102:** 305 (March) 1939.

The author describes the isolated paresis of both superior oblique rectus muscles, discusses the differential diagnosis and compares his data with those of other writers. Detachment of both trochleas during Killian's operation is mentioned in connection with the difficulties met with in the surgical therapy to repair this lesion. Jaensch reports the case of a man, aged 33, who suffered concussion of the brain by falling from a tree. He was unconscious for twelve hours and noticed diplopia on the following day. No neurologic disturbances were found, aside from isolated paresis of both the superior oblique muscles. The Wassermann reaction was negative. Recession of the inferior rectus muscle in the right eye and two weeks later in the left eye having been unsuccessful, myectomy of the left inferior oblique muscle was performed. The result was satisfactory, enabling the patient to obtain binocular single vision in a portion of the upper field on the day after the operation. Diplopia was fairly well eliminated about four months later. No further surgical procedure was undertaken, as the patient saw double only when forced to look to the side or downward, which did not interfere with his work. Wheeler's tucking and advancement of the superior oblique muscles possesses great merit: Its effect may be readily increased by myectomy of one or of both inferior oblique muscles later. Isolated paresis of both trochlear muscles is due probably to a lesion of the origin of the nerves in the anterior medullary velum.

K. L. STOLL.

Operations

LATE EVOLUTION OF AN ORBITAL GRAFT. L. CERISE and G. OFFRET, Arch. d'opht. **2:** 132 (Feb.) 1938.

The authors describe a rare case of the development of a graft in the orbit. The sources of intraorbital grafts, especially living transplants, are well known. Ordinarily a graft in the orbit becomes reduced in size and sometimes after some months becomes atrophied. For this reason some writers have had recourse to glass balls, metal balls, paraffin and dead organic implants. In the case reported a cystic formation took place which was found to contain fluid. The observation of such a case brings up again the question of the choice of the type of implant to be used and suggests that inert material is better than organic.

S. B. MARLOW.

PEDICULATED DERMOMUSCULAR BLEPHAROPLASTY. J. CHARAMIS, Arch. d'opht. **2:** 206 (March) 1938.

In this article Charamis presents with photographs the results obtained in 12 cases of deformities of the lid in which he improved the defects by plastic operations, using a pedunculated flap. He believes that the good results obtained are largely due to the use of this type of flap.

S. B. MARLOW.

Parasites

FIRST CASE OF PHILOPHTHALMOSIS IN MAN. A. MARKOVIC, Arch. f. Ophth. **140:** 515, 1939.

Philophthalmus is the name of a species of trematodes which have a special affinity for the eye, or rather for the conjunctival sac. Lodgment of Philophthalmus in the eye has so far been observed only in birds. Markovic reports a case of acute trachoma-like, unilateral conjunctivitis in a young man which was found to be caused by a worm of the Philophthalmus variety, which was 3.5 mm. long. After removal of the parasite, the conjunctivitis healed promptly. The eyes of a local (Belgrad, Jugoslavia) species of sea gulls (Larus ridibundus) were found to harbor the parasite. The patient had probably become infected while bathing in a river near Belgrad.

P. C. KRONFELD.

Physiology

CONTRAST SENSITIVITY AS A CRITERION OF VISUAL EFFICIENCY AT LOW BRIGHTNESS-LEVELS. M. LUCKIESH and F. K. MOSS, Am. J. Ophth. **22:** 274 (March) 1939.

A report is made on an investigation of the differences among persons in the perception of low contrasts under low brightness-levels. It was found that the subjects possessing the same visual acuity rating as measured by the American Medical Association chart varied rather widely in their ability to recognize the low contrast test objects of the Luckiesh-Moss chart. At low levels of brightness even clear glasses reduce the brightness of objects at least 8 per cent. Obviously tinted glasses will reduce the brightness still more.

W. S. REESE.

CHANGES IN THE CRITICAL FREQUENCY OF LIGHT FLICKER HAVING THE CHARACTER OF CONDITIONED REFLEXES. A. I. BOGOSLOVSKI, Arch. d'opht. **2:** 219 (March) 1938.

This is a report of some flicker experiments showing the effect of auditory excitation on the change in the critical frequency of flicker. If the flicker experiment is repeated several days without the auditory excitement, the reaction becomes acquired and a curve established. These changes in the frequency can be intrepreted as conditioned reflexes. They are influenced by psychic states, and the author believes that in all probability they can be considered as taking place in the sensorial sphere.

S. B. MARLOW.

Refraction and Accommodation

TRANSITORY MODIFICATIONS OF THE REFRACTIVE POWER OF THE OCULAR MEDIA. R. WEEKERS, Compt. rend. Soc. de biol. **132:** 39, 1939.

The refraction of the eyes of rats was determined by skiascopic examination under atropine cycloplegia, first while the animals were on a normal diet and then while they were on rations containing 50 per cent

galactose. In the latter case the dioptric power of the eye constantly increased but returned to the initial refraction after the normal diet was reestablished. These variations of refraction preceded the appearance of cataract as checked by the slit lamp.

J. E. LEBENSOHN.

STABILIZATION: A SUPPLEMENT TO STEIGER'S THEORY. A. KREIKER, Arch. f. Ophth. **140:** 269 (April) 1939.

Little is known about the changes in axial length and refractive power which occur in the human eye during the first few years of life, but it is certain that in principle the axial length increases, whereas the dioptric power decreases. Through this controlled growth of the eye, the final result, namely, the prevalence of emmetropia, is achieved. When growth in the anteroposterior direction comes to an end, the refraction becomes final, or, as Kreiker calls it, stabilized. Stabilization should take place when the refractive media have reached their final shape but may take place before or after that. The myopic conus always indicates delayed stabilization. The time of life at which stabilization takes place is determined by heredity just as the initial axial length and dioptric power of the eye are determined by primordial and not by environmental factors.

P. C. KRONFELD.

Retina and Optic Nerve

THE RETINA IN SEPTIC AND CHRONIC ENDOPHTHALMITIS OF ECTOGENOUS ORIGIN. H. D. LAMB, Am. J. Ophth. **22:** 258 (March) 1939.

Lamb gives the following summary:

"The principal retinal changes are tabulated in the case of 28 eyes with septic endophthalmitis and of seven eyes with chronic endophthalmitis. The 28 eyes with so-called complicated septic endophthalmitis were characterized by at least a small amount of small round-cell infiltration in the ciliary body and choroid together with the exudate of numerous pus cells and macrophages into mainly the anterior or the cyclitic portion of the vitreous. The term chronic endophthalmitis is introduced as a corollary to septic endophthalmitis for the clinical and pathologic diagnosis of eyes showing an exudate into the vitreous that is composed almost altogether of macrophages. The retinal change occurring first in endophthalmitis was perivasculitis. The latter was the source of all the inflammatory round cells that infiltrated the retina and migrated into the vitreous from the retina. In all the eyes tabulated, the macrophage was the predominant cell composing the perivasculitis. Perivasculitis in some degree was present in all but two of the 28 eyes with septic endophthalmitis and in all but two of the seven eyes with chronic endophthalmitis. The number of round cells infiltrating the retina and the number of macrophages from the retina entering the vitreous were generally fewer by far in chronic endophthalmitis than in complicated septic endophthalmitis. The retinal membrane on the inner surface of the retina like the cyclitic membrane was composed of connective tissue produced by fibroblasts that developed from the macrophages in the

vitreous. This retinal membrane is more likely to occur in septic endophthalmitis than in chronic endophthalmitis because more macrophages develop in the former."

W. S. REESE.

IMPORTANCE AND ETIOLOGY OF HOLES IN DETACHMENT OF THE RETINA. A. FUCHS, Arch. d'opht. **2**: 18 (Jan.) 1938.

This paper by Fuchs is divided into two parts. In the first part he discusses the various forms of holes or tears and their frequency and commoner locations. He distinguishes between holes and tears. Holes are round, oval or polygonous and occur singly or in groups. Tears occur as cracks or fissures; they are large sometimes and are horseshoe shaped with a tongue. The third type of defect to produce detachment is the disinsertion. The commonest site of tears is the upper temporal quadrant in front of the equator. The author quotes the statistics of Shapland, Gonin and Meissner. The second part of this report deals with the causation of the tears. Fuchs himself believes that there are many underlying causes. The two chief theories are: the traction theory, which is supported by Leber, Nordenson, Gonin, Lindner and Arruga, and the theory of cystoid degeneration as proposed by Vogt. A third theory is based on congenital fragility of the retina. There seems to be a tendency for the retina to become detached, perhaps due to weaker adhesion between the retina and the choroid. A further proposal is concerned with the stretching of the retina in high myopia. The formation of retinal cysts is mentioned as a fifth factor and coloboma of the choroid and other congenital changes as a sixth factor. The formation of adhesions between the vitreous and the retina secondary to inflammation is the seventh and last possibility mentioned. Fuchs suggests that there are certainly many others. It has been his intent to call attention to the large numbers of causes, their differences and simultaneous action. No one cause explains all cases.

S. B. MARLOW.

THE SYNDROME OF LAURENCE-MOON-BARDET-BIEDL. E. B. STREIFF and C. ZELTNER, Arch. d'opht. **2**: 289 (April) 1938.

This article is a complete review by the authors of this whole subject with an extensive bibliography and a number of family trees. They report in some detail a case of their own. The analysis of all the cases published leads them to the opinion that in order to define this syndrome at least two of the three symptoms must be present. The characteristic symptoms are an adiposogenital dystrophy, polydactylia, peripheral retinitis pigmentosa and mental retardation. The evidence points strongly to heredity as being the cause of the disease. Treatment is of no avail.

S. B. MARLOW.

IRRADIATION THERAPY OF GLIOMA OF THE RETINA. REPORT OF A CASE. J. WEITERSCHAU, Klin. Monatsbl. f. Augenh. **102**: 359 (March) 1939.

The author's purpose in publishing this paper is to show that irradiation of glioma of the retina with roentgen rays and radium has its merits. He refers to the work done along this line by Axenfeld, von Hippel, Hill-

gärtner, Würdemann and others since 1914. In a table he records the data on 14 cases in which retinal gliomas were reported cured by this treatment. He gives as his reason for not fully accepting the verdict that irradiation was responsible for recovery the facts that spontaneous cures of glioma were reported and that the quantity of irradiation used by divers authors varied to such an extent that uniform epicrisis is impossible. Weiterschau reports the case of a child, aged 2 years, with bilateral glioma. The child received irradiation of a 430 per cent skin erythema dose and two treatments of electrocoagulation after Weve's method. Nevertheless, serial sections of the enucleated globe showed intraocular growth of the glioma. Necroses observed in this eyeball could not be definitely attributed to the irradiation or electrocoagulation, as necroses are known to occur in eyes which were not treated in this manner. Some lesions in the cornea, on the other hand, were attributed to the damaging effect of irradiation. The author is of the opinion that enucleation yields a better prognosis quoad vitam than irradiation. The latter procedure is a waste of time, and enucleation should be done as soon as possible. Even in cases in which a cure of the glioma had been obtained by irradiation, enucleation may become necessary to stop severe pain due to secondary glaucoma. Metastases may occur in a phthisic globe, as evidenced by the author's histologic observations. Irradiation of the second eye after removal of the other proved to be an unsatisfactory procedure.

K. L. STOLL.

LARGE HEMORRHAGES IN THE VITREOUS AFTER RETINAL TEARS: REPORT OF A CASE. A. VOGT, Klin. Monatsbl. f. Augenh. **102**: 516 (April) 1939.

Large hemorrhages in the vitreous of elderly persons may be attributed to arteriosclerosis. A man aged 65 struck the back of his head when falling on the ice; no visual impairment was noted. On blowing his nose forcibly a few weeks later, he observed sudden obscuration of vision in his right eye; the fundus could not be examined owing to a large hemorrhage. A few months later Vogt noted a covered hole in the retina. A vessel crossing the lid covering the hole had been torn by force of blowing the nose, after it might have been severed partly as a result of the fall. The hemorrhage in the vitreous persisted partly after closure of the hole by cathalysis and diathermy; vision had been improved, and the field of vision had become normal by readaptation of the retina.

K. L. STOLL.

Trachoma

A STUDY OF TRACHOMA IN INDO-CHINA. P. KELLER, Arch. d'opht. **2**: 1 (Jan.) 1938.

The author presents his personal observations on trachoma seen in Indo-China over a period of about ten years in close to 200,000 persons. He divides the course of the disease into three stages: (1) an initial or nodular (nonfollicular) stage, (2) an evolutional or ulcerative stage and (3) a sclerotic stage. The initial stage is seen in infants and very young children. He states that trachoma is a familial disease with a slow

development. Its progression depends on the environment and possibilities of contact. It is never seen in infants under 1 year. Its progress into the second stage is described. He believes as a result of his observations that trachoma is never unilateral. The second stage is less well defined and its diagnosis difficult. Normally trachoma is not granular but presents rather small ulcerations. The duration of this stage is variable, as the lesion gradually passes over into the sclerosing stage, which is easy to diagnose. The author discusses in some detail the complications that are common. S. B. MARLOW.

Tumors

BILATERAL CHOROIDAL METASTASIS FROM CANCER OF THE BREAST. P. BONNET, Bull. Soc. d'opht. de Paris **51:** 134 (Feb.) 1939.

One year after removal of a breast for cancer a woman of 60 years complained of loss of vision. There was bilateral retinal detachment. There was no transillumination of the right eye; the posterior surface of the lens was covered with hemorrhage; the tension was normal, and there was no pain. The left eye showed only partial detachment with vision of 0.5, and in the macular area there was a quite superficial gray pigmented area, which appeared as an early cancerous process. A film of the lung showed diffuse general metastasis. The diagnosis was confirmed on removal and sectioning of the right eye. L. L. MAYER.

DIKTYOMA OF THE RETINA. V. M. SHEPKALOVA, Vestnik oftal. **13:** 95, 1938.

A blind eye of a child aged 8 was enucleated because of a large staphyloma of the sclera. A white massive tumor filled the whole eye. The histologic examination revealed a malignant nonpigmented tumor which developed from the nonpigmented epithelium of the ciliary body and infiltrated the whole retina. The tumor consisted of cellular membranes and bands with the oblong nuclei arranged in several rows perpendicular to the surface of the cells, resembling the embryonic retina. A number of islands of hyaline cartilage were seen. The histologic character of the tumor led Shepkalova to classify it according to Fuchs's and Boeck's description as a diktyoma of the retina. It usually develops at the age of 1 to 8 years. The cells of the tumor are arranged like membranes with numerous folds, which on section look like canals. At times the bands of the neighboring cells become confluent and form a solid mass which, together with the rosettes, resemble a glioma of the retina. This case is reported because of the rarity of the condition, as this is only the ninth case reported. (B. Klien reported 1 more case in the ARCHIVES in September 1939.—Abstracter.) O. SITCHEVSKA.

Uvea

DIABETIC RUBEOSIS OF THE IRIS. H. FEHRMANN, Arch. f. Ophth. **140:** 354 (April) 1939.

Under the name of rubeosis of the iris Salus in 1928 described the formation of capillary networks on the sphincter portion of the iris. This

condition occurred in diabetic persons and was accompanied by a rise in intraocular tension which could not be controlled by miotics. On the contrary, miotics tended to raise the tension still further. Fehrmann (ophthalmic clinic, University of Kiel) reports 3 cases of this condition, in 1 of which both eyes became available for anatomic examination. The anatomic substratum of the rubeosis consisted of newly formed capillaries in and on the anterior layer of the iris; they were not accompanied by connective tissue and could therefore be distinguished from the vessels in a glaucomatous membrane on the iris. Clinically, rubeosis is always associated with diabetic retinitis and followed by glaucoma of the acute uncompensated type which cannot be controlled by conservative or by surgical means.

P. C. KRONFELD.

Therapeutics

PHENOLIZATION OF THE SPHENOPALATINE GANGLION IN OPHTHALMOLOGY. R. THUREL, Arch. d'opht. **2**: 506 (June) 1938.

Thurel advocates the injection of phenol into the sphenopalatine ganglion, especially for sympatheticalgias. This treatment alleviates the pain in cases of episcleritis, iritis and chronic glaucoma and is beneficial in cases of retrobulbar neuritis. He has used this treatment for neuroparalytic keratitis, apparently with benefit in a number of cases. As a result of the observations which he reports, he believes that the anatomic lesion is not entirely sufficient but that the functional disturbances consisting both of pain and of circulatory changes which lead to hyperexcitability of the sympathetic nervous system are also important. From this standpoint he suggests the possibility of functional disturbances being able to produce the lesions. He is of the opinion that the many surgical procedures on the nose and sinuses derive their benefit from the anesthesia necessary to carry them out rather than from the operation itself.

S. B. MARLOW.

Society Transactions

EDITED BY W. L. BENEDICT

DETROIT OPHTHALMOLOGICAL SOCIETY

PARKER HEATH, M.D., *President*

EDMOND L. COOPER, M.D., *Recorder*

Feb. 13, 1940

Trachoma. DR. ALSON BRALEY.

Clinically, trachoma is characterized by conjunctival follicles and granules and corneal involvement. The conjunctival disease is classified according to MacCallum as follows: I, immature follicles; IIa, mature follicles; IIb, mature follicles with papillary hypertrophy; III, beginning scarring; IV, healing trachoma. The corneal complication has been classified by Thygeson in degrees of involvement by the pannus: first degree, a minimal pannus; fourth degree, a pannus extremely dense.

A diagnosis of trachoma can usually be made by the involvement of the upper tarsal conjunctiva by mature follicles, papillary hypertrophy or scarring, with a pannus of the upper portion of the cornea. If limbic follicles or Herbert's pits are present, the diagnosis is usually evident.

Trachoma is undoubtedly a virus disease, and the elementary body of the inclusion body in the conjunctival epithelial cells probably represents the virus, the classification of which has been difficult. These inclusion bodies are present in the epithelium at the upper edge of the tarsus in all cases of acute early trachoma but are absent in cases of old healing trachoma.

The treatment of trachoma has been rather unsatisfactory until the discovery of the response of the condition to sulfanilamide. Trachoma in the early stages responds almost miraculously to this drug, and in the later stages improvement occurs.

DISCUSSION

DR. GERALD SPERO: I have seen cases of active trachoma in which it was apparently impossible for me to demonstrate inclusion bodies, although the diagnosis of trachoma could not be doubted.

DR. J. C. GEMEROY: There have been some favorable reports regarding the topical application of an aqueous solution of sulfanilamide, and Paton has reported using subconjunctival injection of the drug. Has Dr. Braley any experience with either of these forms of treatment?

DR. HOWELL L. BEGLE: I should like to report results of treatment in 2 cases. Arlene, a white girl of 9 years, had had acute trachoma for two years. The first treatment consisted of mechanical expression of the follicles and local medication. In March 1939 she was admitted to the hospital and for one week was given sulfanilamide by mouth, 15

grains (0.972 Gm.) every four hours. At the present time she shows a complete cure. The second child, Anita, a white girl aged 7, had acute trachoma which had not improved after mechanical expression of the follicles and local treatment. After sulfanilamide therapy in December 1939, she showed marked improvement. A third patient, William, a white boy from Tennessee, has had no treatment, and a definite diagnosis of trachoma has not been made. He is presented as a problem in diagnosis. The tarsal conjunctivas were studded with small follicles extending into the retrotarsal folds. These follicles were flatter than those usually seen in cases of trachoma. Epithelical scrapings showed eosinophilia. Inclusion bodies were not found. The diagnosis in this case is bilateral vernal catarrh.

I should like to call attention to the report of the Council on Pharmacy and Chemistry of the American Medical Association relative to sulfanilamide, its dosage, toxic effects and complications. The Council warns that every patient receiving sulfanilamide should be under daily attention of a physician.

Dr. Alson Braley: Dr. Thygeson found inclusion bodies in 100 per cent of cases of the IIa stage of mature follicle formation. He had difficulty finding them in stage III and never found them in stage IV.

Use of a 2 per cent emulsion of sulfanilamide instilled into the eyes was followed by indifferent results.

Parker Heath, M.D., *President*

Edmond L. Cooper, M.D., *Recorder*

March 28, 1940

Ocular Tuberculosis. Dr. Alan C. Woods, Baltimore.

Tuberculous conjunctivitis in the primary form results from direct infection with bacilli combined with a minor abrasion. Secondary conjunctivitis is an extension from a neighboring focus or from bacilli carried by the blood stream. Six types of secondary conjunctivitis are recognized. Phlyctenular keratoconjunctivitis is probably an allergic phenomenon.

Tuberculous keratitis occurs in the following forms: sclerokeratitis, tuberculous interstitial keratitis, deep central keratitis, tuberculous infiltrates and tuberculous ulcers.

In tuberculous uveitis either the anterior or the posterior uvea may be affected according to whether the infection is carried to the eye by the long or the short ciliary arteries. Anterior tuberculous uveitis affects the iris and the ciliary body as simple iritis, nodular iritis or conglomerate tuberculoma of the iris. Posterior tuberculous uveitis, affecting the choroid, occurs as circumscribed recurrent lesions of the choroid, rapidly spreading choroiditis characterized by acute inflammation, caseation and necrosis, miliary tuberculosis of the choroid, solitary tubercle of the choroid and tuberculoma of the posterior ocular segment.

Tuberculosis of the sclera occurs as a deep anterior scleritis, usually confined to one section of the sclera, although the process may surround the cornea as annular scleritis. Posterior scleritis is the rare sclerotenonitis.

Tuberculosis of the retina occurs as rare superficial exudative inflammation or as tuberculous periphlebitis—Eales's disease.

Optic neuritis as a true tuberculous lesion probably does not occur. Papilledema is commonly seen in cases of tuberculous meningitis due to an extension of the tuberculous process along the sheath of the nerve.

The diagnosis of ocular tuberculosis is often presumptive. The criteria on which a diagnosis is based are: the clinical picture and course of the disease; the elimination of other causal factors, especially focal infection, syphilis and a group of diseases such as brucellosis, sarcoid and yaws, the ocular lesions of which simulate those of tuberculosis; a study of the general tuberculous status of the patient, and the tuberculin reactions.

The pathogenesis of ocular tuberculosis is primarily from an infection of the eye by tubercle bacilli, usually carried to the eye by the blood stream. The nature and course of the resulting lesions are governed by three factors, namely, the number and virulence of the invading organisms, the degree of hypersensitivity to tuberculin possessed by the attacked tissues and the degree of resistance to infection or immunity, both local and general, possessed by the host.

The treatment of ocular tuberculosis comprises three separate points of attack: an enhancement of the general and local immunity, general hygienic regulation, paracentesis and autohemotherapy; the direct attack on the bacilli by chemotherapy, nonspecific protein therapy and phototherapy, and the elimination of the fatal tissue hypersensitivity and the desensitization of the patient to tuberculin.

DISCUSSION

DR. HENRY DUNLAP: I should like to inquire what value Dr. Woods places on the procedure of peritomy in cases of tuberculous keratitis with vascularization. The operation is recommended by some clinicians of wide experience, while others feel that it merely defeats its own purpose.

DR. HAROLD F. FALLS, Ann Arbor, Mich.: Several different preparations of tuberculin are on the market and may be used. It would be interesting to know Dr. Woods's opinion as to their comparative values, especially old tuberculin and purified protein derivative.

DR. ALAN C. WOODS, Baltimore: The growth of new blood vessels into inflamed corneal tissues has a purpose. The blood supply that is brought to the diseased area aids in the healing process, and the consequence of any operation, such as peritomy, which destroys this blood supply merely hinders the healing process.

At the Wilmer Institute old tuberculin is used for diagnosis and Deny's boullion filtrate for treatment. It is felt that emulsions are definitely unreliable. Treatment is begun with small doses of the boullion filtrate and continued for two years at least. Even after tuberculin therapy is complete, it is necessary to keep the patient under observation.

NEW YORK ACADEMY OF MEDICINE, SECTION OF OPHTHALMOLOGY

DAVID WEBSTER, M.D., *Chairman*

ROBERT K. LAMBERT, M.D., *Secretary*

March 18, 1940

Retardation in Reading: A Problem to be Solved Cooperatively STELLA S. CENTER, LITT. D., Director, Reading Clinic, New York University (by invitation).

At all school levels, including college and university, and at adult levels, failure to read efficiently is a national problem of primary importance. Reading has two aspects: physiologic and mental. A large percentage of retarded readers have ocular disabilities: either muscular imbalance or refractory difficulties. Muscular weakness and irregularities of refraction prevents the pupil's establishing habits conducive to efficient reading. The problem of retardation in reading is one that must be solved cooperatively but chiefly by ophthalmologists and well trained teachers. A reading clinic provides opportunity for such cooperation.

Reading Disability from a Neurologic Point of View. DR. EARL C. CHESHER (by invitation).

In order to show the anatomic and physiologic factors that influence reading aptitude, cases are cited in which localized cerebral pathologic lesions result in loss of reading ability. This disability is compared with that of the child who, despite good vision, good intelligence and adequate schooling, is unable to learn to read. It is assumed that the latter disability is a developmental defect analogous to the acquired form. Classification according to the degree of disability is suggested. Principles which underlie remedial work were discussed and suggestions for determining progress made.

Effect of Vision on Reading Disability. DR. BRITTAIN F. PAYNE.

The conclusions made from a study of 42 persons complaining of reading disability showed:

1. Binocular single vision with depth perception or third grade fusion is essential for efficient reading.

2. Patients with heterophoria are helped by orthoptic exercises and correction of refractive errors.

3. Patients with heterotropia are not helped appreciably by orthoptic training and correction of refractive errors.

DISCUSSION OF PAPERS BY DRS. CENTER, CHESTER AND PAYNE

DR. CONRAD BERENS: It is encouraging to hear this discussion of reading difficulties by such a representative group, because it is my firm conviction, after studying patients in the Reading Disability Clinic at the New York Eye and Ear Infirmary for the last four years, that it is only by properly correlated studies by experts in various fields of medicine and education that the answer to the individual patient's problems will be found.

Possibly the ophthalmologist may have been slow in recognizing the importance of reading disability, and he has not always made the type of examination that persons with such disability require. Furthermore, when children complained of inability to use their eyes efficiently in school, the ophthalmologist has sometimes considered the chapter closed when he has pronounced the eyes healthy, forgetting the educational, mental and possibly even the physical side of the problem.

Patients have been referred for an examination of the eyes after a year's treatment for their reading disability, only to find that they had a remote (300 mm.) poorly sustained near point of convergence or some other serious ocular condition. On the other hand, I have been negligent in treating patients without realizing the need for obtaining the cooperation of other specialists in the field of reading until much valuable time had been lost.

The examination at the New York Eye and Ear Infirmary includes a routine external and internal examination of the eye, a complete examination of motor anomalies, studies of fatigue of accommodation and

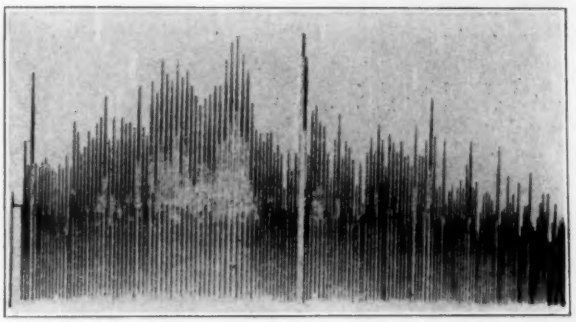


Fig. 1.—Record of accommodative fatigue in boy 12 years of age. Note the ascending graph for approximately three minutes and the descending graph for the last four minutes. Physical and laboratory examinations gave negative results except for a basal metabolic rate of —25.

convergence, complete studies of the visual fields and an examination for aniseikonia. In certain cases defects have been found which were important in each one of these examinations. But without the correlated studies with psychologists, neuropsychiatrists and physicians there would be many more failures than are recorded. In some cases serious physical disability has been found. One patient referred by Dr. Center was found to have chronic hyperplastic ethmoiditis, and it was not until this condition and a secondary convergence insufficiency were controlled that the boy showed improvement in reading under Dr. Center's guidance.

The subject of fatigue and blurring of print were mentioned by Dr. Center and Dr. Chesher. Several of the patients at the New York Eye and Ear Infirmary, even very young patients, have shown rapid fatigue of accommodation. The record of accommodative fatigue made by one of these patients is shown in figure 1. The boy, 12 years of age, had a basal metabolic rate of — 25, but until the basal metabolism test

was made his general physician had reported negative findings for the physical examination. A normal near point of accommodation does not always exclude rapid fatigue of accommodation.

Aniseikonia has also apparently been a factor, as suggested by Dr. Payne, in certain cases. A diagnosis of reading disability was made for 68 (6.9 per cent) of 978 patients referred to the department of aniseikonia of the New York Eye and Ear Infirmary. Of this number, the disability of 8 could not be measured; 20 had no aniseikonia and 40 had aniseikonia; 21 (31 per cent) wore iseikonic glasses. Of the 21 who wore iseikonic glasses, 10 reported no change in reading disability; 11 (15 per cent) reported improvement in reading ability—that is, 52.3 per cent of 21 patients who wore their iseikonic lenses reported improvement. In several instances iseikonic lenses have seemed to be of benefit for a time, and then sometimes with and sometimes without orthoptic training the need for the lenses had passed. Many of the patients who say they are improved by an iseikonic correction are hypersensitive, and it is difficult to evaluate the importance of the aniseikonia.

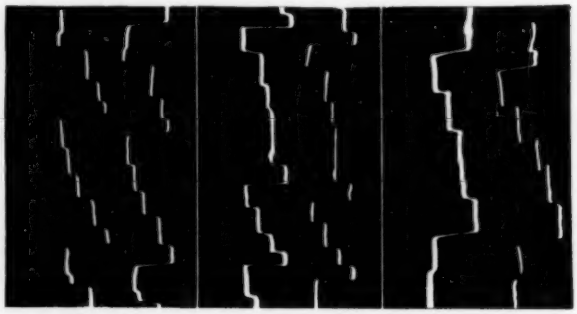


Fig. 2.—Effect of lowered oxygen tension on ocular movements. These records, made in 12.5 and 10.5 per cent of oxygen (13,500 and 17,500 feet), show marked irregularities. Left hyperphoria is manifested by an increase in the distance between the tracks. The record on the left is a control; that in the middle was made in 12.5 per cent of oxygen and that on the right in 10.5 per cent of oxygen (McFarland, Knehr and Berens).

My experience has coincided with Dr. Payne's findings in regard to motor anomalies, for convergence insufficiency and convergence excess have given great difficulty, and in some cases latent hyperphoria seemed to be a factor. In 1 case the hyperphoria was shown to be an important factor only when oxygen tension was lowered (fig. 2).

I have shown, in conjunction with Dr. McFarland and Dr. Knehr, the effect of deprivation of oxygen on reading, and in figure 3 the effect of reduced oxygen on ocular movements is pictured graphically. Possibly some important ocular conditions which might interfere with reading are not discovered by the tests usually employed.

Dr. Center has stressed the fact that if the intelligence quotient is too low it is almost impossible to train a child to read. I have also found this to be a factor in several patients, especially those who had arrested

mental development. The cooperation of a neuropsychiatrist has been obtained, but I have found, as Dr. Chesher has, that this type of patient is usually most unsatisfactory from the standpoint of treatment.

I am glad Dr. Chesher has removed the fear that some ophthalmologists have had concerning reversals in young patients.

Proper care of reading difficulties is similar to many of the orthoptic problems, and frequently they go hand in hand. As in orthoptic training, there is no substitute for a careful, complete group examination followed by the prolonged individualized and frequently repeated treatment which reeducates the patients in every possible way.

There is no question but that each ophthalmologist here has been stimulated to give greater consideration to reading disability and that he will know better how to cooperate with other specialists in the management of these patients who need his help.

DR. JOSEPH IRVING PASCAL: I want to ask Dr. Center how one evaluates the relative importance of the two elements in efficient reading,

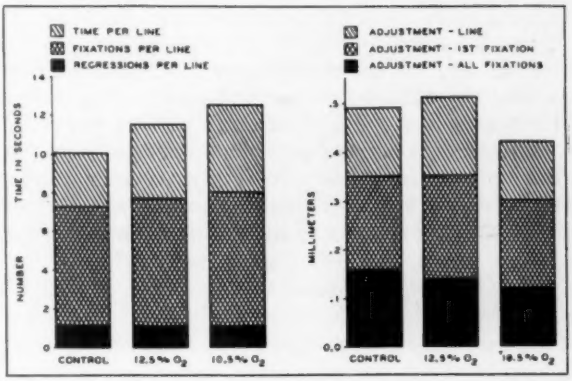


Fig. 3.—Effect of reduced oxygen on ocular movements (McFarland, Knehr and Berens).

that is, speed and comprehension? How does one rate two students, one of whom reads 300 words a minute, with 100 per cent comprehension, and the other of whom reads 400 words a minute, with only 80 per cent comprehension?

DR. STELLA S. CENTER: Comprehension is the most important factor of all. Speed is not important unless there is efficient comprehension. A low rate of speed is preferred with a high degree of comprehension, rather than a high rate of speed and a low degree of comprehension.

DR. BENJAMIN FRIEDMAN: I was interested in Dr. Center's paper because it describes the problem in its natural environment—the classroom. A certain number of persons who suffer from reading difficulties have a major muscular or refractive difficulty, and these are corrected by the ophthalmologist as far as possible. But the reports which simply indicate a muscular imbalance or a refractive error are relatively mean-

ingless, because a small refractive error has little effect on the patient's comfort or efficiency, and the same is true of a small muscular imbalance. Furthermore, it seems to me that the desired horizontal swing which the graphs indicate is the result of a mental function rather than the result of an ocular difficulty proper. Possibly the improvement in the environment of the child, when the patient is brought into a special classroom and given the special instruction which is available to this particular group, is the decisive element in the treatment. I think it is possible that the problem might best be attacked from that angle rather than from the ophthalmic angle, and perhaps it is unwise to overestimate the function of the ophthalmologist in this realm.

DR. A. L. KORNZWEIG: What is the effect of left-eyed dominance on reading ability? Can the reading ability be improved when left ocular dominance is present?

DR. STELLA S. CENTER: This is a highly debatable matter, and no attempt is made at the clinic to change left handedness. An attempt is made to make the student as comfortable as possible. It is felt that little is known about the relation of left handedness to reading. It is largely a question of mental training. It is not known whether the training of the eye precedes the mental changes, or whether the training of the mind brings about the changes in ocular habits. A great many of the very disabled readers have these confusions. What the connection is I do not know, and no effort is made to make any changes in that direction. The child with his left handedness is simply accepted, and an attempt is made to teach him reading as though he were normal in that respect. I have observed that a great many of the disabled readers are left handed.

Book Reviews

Fundus Atlas. Stereoscopic Photographs of the Fundus Oculi. By Dr. Louis Bothman, Clinical Professor of Ophthalmology, University of Chicago, and Reuel W. Bennet, Chicago. Price, $17, express prepaid. Chicago: The Year Book Publishers, Inc., 1939.

This atlas consists of 50 photographic reproductions of the following conditions of the fundus: physiologic excavation of the optic nerve (cylindric type), physiologic excavation of the optic nerve (bowl shaped), vascular loops of retina, epipapillary membrane, persistent hyaloid artery, small coloboma of the optic nerve with conus below, congenital posterior staphyloma, optic nerve pit, glaucomatous excavation of the disk, pseudo optic neuritis, medullated optic nerve fibers, hyaline bodies (drusen) of the disk, papilledema without hemorrhage, papilledema with hemorrhage, myopic crescent, posterior staphyloma in myopia, macular changes in myopia, early diabetic retinitis, diabetic retinitis, proliferating retinitis with retinal detachment in diabetes, localized retinal arteriosclerosis and choroidal sclerosis, nephritic retinitis (advanced), hypertensive neuroretinopathy, stellate figure with a macular cyst, hypertensive neuroretinopathy, proliferating retinitis in an arteriosclerotic fundus, preretinal hemorrhage, thrombosis of the central retinal vein, thrombosis of the superior temporal vein, retinal arteriosclerosis with atrophy of the optic nerve, retinal detachment from choroidal sarcoma, flat retinal detachment (traumatic), proliferating retinitis (traumatic), foreign body in the retina, retinitis pigmentosa, retinitis punctata albescens, chorioretinitis with exudate, diffuse recurrent choroiditis, healed solitary tubercle of the choroid, disseminated choroiditis, coloboma of the macula, hole in the macula, central chorioretinitis, drusen of the macula, senile macular degeneration, macular edema, disciform degeneration of the macula of the juvenile type, disciform degeneration of the macula of the senile type, nevus of the choroid with hemorrhage and detachment of the vitreous.

The pictures were taken with the reflex free Nordenson camera. They are magnified three or more times with a special stereoscopic enlarger devised by R. W. Bennet, photographer for the division of ophthalmology, the University of Chicago.

The photographs are stereoscopic and are printed on cardboard; the history of the patient and the result of the examination are added.

The photographs are excellent; in fact, they are much better than the usual fundus photographs and will serve admirably for study and teaching. Many of the pictures are most successful in depicting the lesions of the fundus, and it is to be hoped that a supplement to complete the atlas will soon be forthcoming, as there are a number of subjects which, in the reviewer's opinion, should be included. The atlas can be warmly recommended to students and practitioners.

ARNOLD KNAPP.

Modern Trends in Ophthalmology. Edited by Frederick Ridley, M.D., and Arnold Sorsby, M.D. Price, 30 shillings. Pp. 698, with 271 illustrations, some in colors. London: Butterworth & Co., Ltd., 1940.

Dr. Ridley and Dr. Sorsby have had the original idea of presenting the advances in ophthalmology as they occur between the periodical and the textbook stages. This is a more exhaustive and pretentious elaboration of the excellent "Recent Advances" series. In short, it is a presentation of the "emergent tendencies and formative influences" of ophthalmology as a specialty and in a closer relation to general medicine. The editors have been assisted by 56 eminent collaborators, who represent the following countries: Great Britain, 28; United States, 9; the Netherlands, 5; France, 4; Sweden, 4; Germany, 3 (now living in other countries); Russia, 2; Switzerland, 1; Belgium, 1, and Hungary, 1.

The subjects are grouped under sections with the following headings: I, "Ophthalmology in Relation to General Medicine," subdivided into sections dealing with infection, allergy and immunity, ocular manifestations of some general disturbances and ocular manifestations of some dystrophies; II, "Diagnostic Procedures;" III, "Refraction and Binocular Vision;" IV, "Physiology of Vision;" V, "Some Newer Conceptions in Pathology;" VI, "Treatment," and VII, "Social Aspects."

There are 57 articles. The following subjects, with their authors, show the completeness of the work: "Virus Disease" (Perdreau), "Ocular Association of Diseases of the Skin" (Grönblad), "Phakomatoses" (Van der Hoeve), "Ophthalmic Dynamometry" (Bailliart), "Treatment of Squint and Heterophobia" (Pugh), "Contact Lenses" (Thier), "Biochemistry and Metabolism of the Eye" (Fischer), "Keratoconjunctivitis Sicca" (Sjögren), "Diathermy Treatment of Retinal Detachment" (Weve) and "Transplantation of the Cornea" (Filatow). Each article is brief and adequately and excellently illustrated, and important literary references are added.

The editors, Dr. Ridley and Dr. Sorsby, are to be complimented on the excellent idea which instigated this book and on their choice of admirable collaborators. The book can be earnestly recommended to every practicing ophthalmologist, who will find the transitional subjects of his specialty presented in a readable and instructive form. The printing and illustrations, many in colors, are most creditable.

ARNOLD KNAPP.

Polychromatic Plates for Testing Colour Vision. By Dr. E. B. Rabkin, Director of the Ukrainian Memorial Central Ophthalmic Institute, Kharkov. Second edition. Pp. 40, with 20 colored plates. Publisher: State Medical Publishing House of the Union of Soviet Socialist Republics, 1939.

The rapid exhaustion of the first edition of this book showed its popularity. There is no particular change in the second edition. Attention is again drawn to the observation of the directions and rules in the use of this method for determining defects in color vision. The number of plates has been increased for differential diagnosis, but the series in general has not been enlarged. Three new plates, 10, 11 and 13, are inserted to replace plates 6, 12 and 15. The experimental

work in the selection of the color combinations has been done as before in the laboratory for color vision of the Hirshman Ophthalmic Institute and in the Second Ophthalmic Clinic of the Kharkov University.

ARNOLD KNAPP.

DISCUSSION ON ARTICLE BY DR. JOHN B. HITZ

[This article appears on page 221 of this issue.]

DR. A. D. RUEDEMANN, Cleveland: The lack of correlation between the results of Dr. Hitz's tests and those of the Betts test may lie in the fact that Dr. Hitz does not use a vertical muscle test or a test for stereopsis. It is possible that if he had used a greater variety of test cards a larger number of errors would have been found merely by the law of averages.

Most children are not equal to accurate muscle tests until they reach the age of 8 or 9 years. Possibly an attempt is being made to make up for an inadequate school system or inadequate teaching by trying to prove that most children have poor eyesight rather than receive poor instruction.

It seems to me that the proper procedure would be to find out if the child has a visual defect by ascertaining if certain clinical signs or symptoms are present, such as headaches and dizziness, and that the question of reading difficulty should be left for a competent oculist. I do not believe that one can turn over to any lay person the important decision as to whether a child should carry on with his reading or whether he should be sent to an oculist. There are psychiatric problems which are also involved. I do not believe that the screening out of muscle errors is the answer to the problem of visual testing in the schools. Having seen a great number of children who have been tested in the psychiatric division because of reading handicaps, I have concluded that refractive errors and muscle disturbances are not the chief causes of inability to get along well in school. The school systems are to blame for a great deal of the difficulties by starting the children to learn to read too early. It is not necessary that a child be taught to read at the age of 6. Many of them are not mentally or physically equipped to do so. It would be advisable for such children to be placed in groups and allowed more time for play.

Reading is the most important subject in a child's life. The responsibility of his eyesight is a medical one, and the number of children going to school for the first time each year is not so great but that the ocular examination card might well accompany the child.

DR. JOHN B. HITZ, Milwaukee: I should like to make a further plea for standardization of tests which are now used or which are approved. If one did nothing more than to standardize the lighting on the Snellen chart, a great deal would be accomplished. There is no good substitute for a careful ocular examination or carefully trained observation of the children as they do their work in school, with a meticulous listing of symptoms. Any screening test in the schools is at best a filler-in until the time one can examine all of these children thoroughly and individually.

Directory of Ophthalmologic Societies *

INTERNATIONAL

International Association for Prevention of Blindness

President: Dr. P. Bailliart, 66 Boulevard Saint-Michel, Paris, 6e, France.
Secretary-General: Prof. M. Van Duyse, Université de Gand, Gand, Prov. Ostflandern, Belgium.
All correspondence should be addressed to the Secretariat, 66 Boulevard Saint-Michel, Paris, 6e, France.

International Ophthalmologic Congress

President: Prof. Nordenson, Serafimerlasarettet, Stockholm, Sweden.
Secretary: Dr. Ehlers, Jerbanenegade 41, Copenhagen, Denmark.

International Organization Against Trachoma

President: Dr. A. F. MacCallan, 33 Welbeck St., London, W., England.

FOREIGN

All-India Ophthalmological Society

President: Dr. B. K. Narayan Rao, Minto Ophthalmic Hospital, Bangalore.
Secretary: Dr. G. Zachariah, Flitcham, Marshall's Rd., Madras.

British Medical Association, Section on Ophthalmology

President: Dr. W. Clark Souter, 9 Albyn Pl., Aberdeen, Scotland.
Secretary: Dr. Frederick Ridley, 12 Wimpole St., London, W. 1.

Chinese Ophthalmology Society

President: Dr. C. H. Chou, 363 Avenue Haig, Shanghai.
Secretary: Dr. F. S. Tsang, 221 Foochow Rd., Shanghai.

Chinese Ophthalmological Society of Peiping

President: Dr. H. T. Pi, Peiping Union Medical College, Peiping.
Secretary: Dr. C. K. Lin, 180 Hsi-Lo-yen, Chienmeng, Peiping.
Place: Peiping Union Medical College, Peiping. Time: Last Friday of each month.

German Ophthalmological Society

President: Prof. W. Lohlein, Berlin.
Secretary: Prof. E. Engelking, Heidelberg.
Place: Heidelberg. Time: Aug. 5-7, 1940.

Hungarian Ophthalmological Society

President: Prof. H. G. Ditroi, Szeged.
Assistant Secretary: Dr. Stephen de Grosz, University Eye Hospital, Maria ucca 39, Budapest.
All correspondence should be addressed to the Assistant Secretary.

Midland Ophthalmological Society

President: Dr. W. Niccol, 4 College Green, Gloucester, England.
Secretary: Mr. T. Harrison Butler, 61 Newhall St., Birmingham 3, England.
Place: Birmingham and Midland Eye Hospital.

* Secretaries of societies are requested to furnish the information necessary to make this list complete and keep it up to date.

NORTH OF ENGLAND OPHTHALMOLOGICAL SOCIETY

President: Dr. A. MacRae, 6 Jesmond Rd., Newcastle-upon-Tyne, England.
Secretary: Dr. Percival J. Hay, 350 Glossop Rd., Sheffield 10, England.
Place: Manchester, Bradford, Leeds, Newcastle-upon-Tyne, Liverpool and Sheffield, in rotation. Time: October to April.

OPHTHALMOLOGICAL SOCIETY OF AUSTRALIA

President: Dr. A. James Flynn, 135 Macquarie St., Sydney.
Secretary: Dr. D. Williams, 193 Macquarie St., Sydney.
Place: Perth, Western Australia. Time: Sept. 2 and 7, 1940.

OPHTHALMOLOGICAL SOCIETY OF EGYPT

President: Prof. Dr. Mohammed Mahfouz Bey, Government Hospital, Alexandria.
Secretary: Dr. Mohammed Khalil, 4 Baehler St., Cairo.
All correspondence should be addressed to the Secretary, Dr. Mohammed Khalil.

OPHTHALMOLOGICAL SOCIETY OF THE UNITED KINGDOM

President: Mr. T. Harrison Butler, 61 Newhall St., Birmingham 3, England.
Secretary: Mr. L. H. Savin, 7 Queen St., London, W. 1, England.

OPHTHALMOLOGY SOCIETY OF BOMBAY

President: Dr. D. D. Sathaye, 127 Girgaum Rd., Bombay 4, India.
Secretary: Dr. H. D. Dastur, Dadar, Bombay 14, India.
Place: H. B. A. Free Ophthalmic Hospital, Parel, Bombay 12. Time: First Friday of every month.

OXFORD OPHTHALMOLOGICAL CONGRESS

Master: Dr. Percival J. Hay, 350 Glossop Rd., Sheffield 10, England.
Secretary-Treasurer: Dr. F. A. Anderson, 12 St. John's Hill, Shrewsbury, England.

PALESTINE OPHTHALMOLOGICAL SOCIETY

President: Dr. Arieh Feigenbaum, Abyssinian St. 15, Jerusalem.
Secretary: Dr. E. Sinai, Tel Aviv.

POLISH OPHTHALMOLOGICAL SOCIETY

President: Dr. W. Kapuściński, 2 Waly Batorego, Poznań.
Secretary: Dr. J. Sobański, Lindley'a 4, Warsaw.
Place: Lindley'a 4, Warsaw.

ROYAL SOCIETY OF MEDICINE, SECTION OF OPHTHALMOLOGY

President: Dr. Malcolm Hepburn, 111 Harley St., London, W. 1, England.
Secretary: Dr. C. Dee Shapland, 15 Devonshire Pl., London, W. 1, England.

SOCIEDADE DE OPHTALMOLOGIA E OTO-RHINO-LARYNGOLOGIA DA BAHIA

President: Dr. Francisco Ferreira, Pitangueiras 15, Brotas, S. Salvador, Brazil.
Secretary: Dr. Adroaldo de Alencar, Brazil.
All correspondence should be addressed to the President.

SOCIETÀ OFTALMOLOGICA ITALIANA

President: Prof. Dott. Giuseppe Ovio, Ophthalmological Clinic, University of Rome, Rome.
Secretary: Prof. Dott. Epimaco Leonardi, Via del Gianicolo, 1, Rome.

SOCIÉTÉ FRANÇAISE D'OPHTALMOLOGIE

Secretary: Dr. René Onfray, 6 Avenue de la Motte Picquet, Paris, 7e.

SOCIETY OF SWEDISH OPHTHALMOLOGISTS

President: Prof. K. G. Ploman, Stockholm.
Secretary: Dr. K. O. Granström, Södermalmstorg 4 IIIl tr., Stockholm, Sö.

TEL AVIV OPHTHALMOLOGICAL SOCIETY

President: Dr. D. Arieh-Friedman, 96 Allenby St., Tel Aviv, Palestine.
Secretary: Dr. Sadger Max, 9 Bialik St., Tel Aviv, Palestine.

NATIONAL

AMERICAN MEDICAL ASSOCIATION, SCIENTIFIC ASSEMBLY, SECTION ON OPHTHALMOLOGY

Chairman: Dr. Albert C. Snell, 53 S. Fitzhugh St., Rochester, N. Y.
Secretary: Dr. Derrick Vail, 441 Vine St., Cincinnati.
Place: Cleveland.

AMERICAN ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY, SECTION ON OPHTHALMOLOGY

President: Dr. Frank E. Brawley, 30 N. Michigan Ave., Chicago.
Executive Secretary-Treasurer: Dr. William P. Wherry, 1500 Medical Arts Bldg., Omaha.
Place: Cleveland. Time: Oct. 6-11, 1940.

AMERICAN OPHTHALMOLOGICAL SOCIETY

President: Dr. F. P. Calhoun, 478 Peachtree St. N. E., Atlanta, Ga.
Secretary-Treasurer: Dr. Eugene M. Blake, 303 Whitney Ave., New Haven, Conn.

ASSOCIATION FOR RESEARCH IN OPHTHALMOLOGY, INC.

Chairman: Dr. John Evans, 23 Schermerhorn St., Brooklyn.
Secretary-Treasurer: Dr. C. S. O'Brien, University Hospital, Iowa City.

CANADIAN MEDICAL ASSOCIATION, SECTION ON OPHTHALMOLOGY

President: Dr. Alexander E. MacDonald, 170 St. George St., Toronto.
Secretary-Treasurer: Dr. L. J. Sebert, 170 St. George St., Toronto.

NATIONAL SOCIETY FOR THE PREVENTION OF BLINDNESS

President-Emeritus: Mr. William Fellowes Morgan, 50 W. 50th St., New York.
Secretary: Miss Regina E. Schneider, 50 W. 50th St., New York.
Executive Director: Mrs. Eleanor Brown Merrill, 50 W. 50th St., New York.

SECTIONAL

ACADEMY OF MEDICINE OF NORTHERN NEW JERSEY, SECTION ON EYE, EAR, NOSE AND THROAT

President: Dr. Charles W. Barkhorn, 223 Roseville Ave., Newark.
Secretary: Dr. William F. McKim, 317 Roseville Ave., Newark.
Place: 91 Lincoln Park South, Newark. Time: 8:45 p. m., second Monday of each month, October to May.

CENTRAL WISCONSIN SOCIETY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. E. G. Nadeau, 122 E. Walnut St., Green Bay.
Secretary: Dr. G. L. McCormick, 626 S. Central Ave., Marshfield.
Place: Green Bay. Time: October 1940.

NEW ENGLAND OPHTHALMOLOGICAL SOCIETY

President: Dr. William D. Rowland, 84 Commonwealth Ave., Boston.
Secretary-Treasurer: Dr. Trygve Gundersen, 243 Charles St., Boston.
Place: Massachusetts Eye and Ear Infirmary, 243 Charles St., Boston. Time: 8 p. m., third Tuesday of each month from November to April, inclusive.

PACIFIC COAST OTO-OPHTHALMOLOGICAL SOCIETY

President: Dr. Isaac H. Jones, 635 S. Westlake Ave., Los Angeles, Calif.
Secretary-Treasurer: Dr. C. Allen Dickey, 450 Sutter St., San Francisco.

PUGET SOUND ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President: Dr. Clarence W. Shannon, 4th and Pike Bldg., Seattle.
Secretary-Treasurer: Dr. Purman Dorman, 1215–4th Ave., Seattle.
Place: Seattle or Tacoma, Wash. Time: Third Tuesday of each month, except June, July and August.

ROCK RIVER VALLEY EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. W. E. Rideout, 27 E. Stephenson St., Freeport, Ill.
Secretary-Treasurer: Dr. J. J. Potter, 303 N. Main St., Rockford, Ill.
Place: Rockford, Ill., or Janesville or Beloit, Wis. Time: Third Tuesday of each month from October to April, inclusive.

SAGINAW VALLEY ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. M. Kessler, 311 Center Ave., Bay City, Mich.
Secretary-Treasurer: Dr. J. H. Curts, 330 S. Washington Ave., Saginaw, Mich.
Place: Saginaw or Bay City, Mich. Time: Second Tuesday of each month, except July and August.

SIOUX VALLEY EYE AND EAR ACADEMY

President: Dr. J. C. Davis, 1615 Howard St., Omaha.
Secretary-Treasurer: Dr. J. E. Dvorak, 408 Davidson Bldg., Sioux Falls, S. D.

SOUTHERN MEDICAL ASSOCIATION, SECTION ON EYE, EAR, NOSE AND THROAT

Chairman: Dr. Grady E. Clay, Medical Arts Bldg., Atlanta, Ga.
Secretary: Dr. John R. Hume, 921 Canal St., New Orleans.

SOUTHWESTERN ACADEMY OF EYE, EAR, NOSE AND THROAT

President: Dr. Dake Biddle, 123 S. Stone Ave., Tucson, Ariz.
Secretary: Dr. A. E. Cruthirds, 15 E. Monroe St., Phoenix, Ariz.

SOUTHWESTERN MICHIGAN TRIOLOGICAL SOCIETY

President: Dr. J. K. Heckert, 103 N. Washington St., Lansing.
Secretary-Treasurer: Dr. W. D. Irwin, 710 Hanselman Bldg., Kalamazoo.
Time: Third Thursday of alternate months.

WESTERN PENNSYLVANIA EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. Hugh B. Barclay, 111 S. Main St., Greensburg.
Secretary-Treasurer: Dr. J. McClure Tyson, Deposit Nat'l Bank Bldg., DuBois.

STATE

ARKANSAS STATE MEDICAL SOCIETY, EYE, EAR, NOSE AND THROAT SECTION

President: Dr. R. R. Kirkpatrick, 6th and Walnut Sts., Texarkana, Ark.
Secretary-Treasurer: Dr. Raymond C. Cook, 701 Main St., Little Rock.

COLORADO OPHTHALMOLOGICAL SOCIETY

President: Dr. William M. Bane, 1612 Tremont Pl., Denver.
Secretary: Dr. Harry Shankel, Republic Bldg., Denver.
Place: University Club, Denver. Time: 7:30 p. m., third Saturday of each month, October to May, inclusive.

CONNECTICUT STATE MEDICAL SOCIETY, SECTION ON EYE, EAR, NOSE AND THROAT

President: Dr. W. E. McClellan, 750 Main St., Hartford.
Secretary-Treasurer: Dr. S. J. Silverberg, 201 Park St., New Haven.

EYE, EAR, NOSE AND THROAT CLUB OF GEORGIA

President: Dr. E. N. Maner, 247 Bull St., Savannah.
Secretary-Treasurer: Dr. C. K. McLaughlin, 567 Walnut St., Macon.
Place: Macon. Time: May 13-17, 1941.

INDIANA ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President: Dr. F. McK. Ruby, Union City.
Secretary: Dr. Edwin W. Dyar Jr., 23 E. Ohio St., Indianapolis.
Place: French Lick. Time: First Wednesday in April.

IOWA ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President: Dr. J. K. Von Lackum, 117–3d St. S.E., Cedar Rapids.
Secretary-Treasurer: Dr. B. M. Merkel, 604 Locust St., Des Moines.
Place: Cedar Rapids. Time: November 1940.

LOUISIANA-MISSISSIPPI OPHTHALMOLOGICAL AND OTOLARYNGOLOGICAL SOCIETY

President: Dr. D. C. Montgomery, 301 Washington Ave., Greenville, Miss.
Secretary-Treasurer: Dr. Edley H. Jones, 1301 Washington St., Vicksburg, Miss.

MICHIGAN STATE MEDICAL SOCIETY, SECTION OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

Chairman: Dr. O. B. McGillicuddy, 124 W. Allegan St., Lansing.
Secretary: Dr. R. G. Laird, 116 Fulton St., Grand Rapids.

MINNESOTA ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. Erling Wilhelm Hansen, 78 S. 9th St., Minneapolis.
Secretary-Treasurer: Dr. George E. McGeary, 920 Medical Arts Bldg., Minneapolis.
Time: Second Friday of each month from October to May.

MONTANA ACADEMY OF OTO-OPHTHALMOLOGY

President: Dr. Roy Grigg, Bozeman.
Secretary: Dr. A. W. Morse, 507 Phoenix Bldg., Butte.

NEBRASKA ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. W. Howard Morrison, 1500 Medical Arts Bldg., Omaha.
Secretary-Treasurer: Dr. John Peterson, 1307 N St., Lincoln.

NEW JERSEY STATE MEDICAL SOCIETY, SECTION ON OPHTHALMOLOGY, OTOLOGY AND RHINOLARYNGOLOGY

Chairman: Dr. Edgar P. Cardwell, 47 Central Ave., Newark.
Secretary: Dr. Arthur E. Sherman, 243 S. Harrison St., East Orange.
Place: Atlantic City. Time: June 3-5, 1941.

NEW YORK STATE MEDICAL SOCIETY, EYE, EAR, NOSE AND THROAT SECTION

Chairman: Dr. Searle B. Marlow, 109 S. Warren St., Syracuse.
Secretary: Dr. C. Stewart Nash, 277 Alexander St., Rochester.

NORTH CAROLINA EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. A. G. Woodward, 100 S. James St., Goldsboro.
Secretary-Treasurer: Dr. M. R. Gibson, Professional Bldg., Raleigh.

NORTH DAKOTA ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President: Dr. N. A. Youngs, 322 De Mers Ave., Grand Forks.
Secretary-Treasurer: Dr. F. L. Wicks, 516–6th St., Valley City.

OREGON ACADEMY OF OPHTHALMOLOGY AND OTO-LARYNGOLOGY

President: Dr. Paul Bailey, 833 S. W. 11th Ave., Portland.
Secretary-Treasurer: Dr. R. S. Fixott, 1020 S. W. Taylor St., Portland.
Place: Good Samaritan Hospital, Portland. Time: Third Tuesday of each month.

RHODE ISLAND OPHTHALMOLOGICAL AND OTOLOGICAL SOCIETY

Acting President: Dr. N. Darrell Harvey, 112 Waterman St., Providence.
Secretary-Treasurer: Dr. Linley C. Happ, 124 Waterman St., Providence.
Place: Rhode Island Medical Society Library, Providence. Time: 8:30 p. m., second Thursday in October, December, February and April.

SOUTH CAROLINA SOCIETY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. E. W. Carpenter, 200 E. North St., Greenville.
Secretary: Dr. J. W. Jervey Jr., 101 Church St., Greenville.
Place: Columbia. Time: November 1940.

TENNESSEE ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. Wesley Wilkerson, 700 Church St., Nashville.
Secretary-Treasurer: Dr. W. D. Stinson, 124 Physicians and Surgeons Bldg., Memphis.

TEXAS OPHTHALMOLOGICAL AND OTO-LARYNGOLOGICAL SOCIETY

President: Dr. J. W. Ward, 2607½ Lee St., Greenville.
Secretary: Dr. Dan Brannin, 929 Medical Arts Bldg., Dallas.
Place: Fort Worth. Time: Dec. 13-14, 1940.

UTAH OPHTHALMOLOGICAL SOCIETY

President: Dr. A. E. Callaghan, Boston Bldg., Salt Lake City.
Secretary-Treasurer: Dr. Rowland H. Merrill, 1010 First National Bank Bldg., Salt Lake City.
Place: University Club, Salt Lake City. Time: 7:00 p. m., third Monday of each month.

VIRGINIA SOCIETY OF OTO-LARYNGOLOGY AND OPHTHALMOLOGY

President: Dr. George G. Hawkins, Newport News.
Secretary-Treasurer: Dr. Guy Fisher, 3 E. Beverley St., Staunton.

WEST VIRGINIA STATE MEDICAL ASSOCIATION, EYE, EAR, NOSE AND THROAT SECTION

President: Dr. George Traugh, 309 Cleveland Ave., Fairmont.
Secretary: Dr. Welch England, 621½ Market St., Parkersburg.

LOCAL

AKRON ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. George E. Black, 7 W. Bowery St., Akron, Ohio.
Secretary-Treasurer: Dr. C. R. Andersen, 106 S. Main St., Akron, Ohio.
Time: First Monday in January, March, May and November.

ATLANTA EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. Stacy C. Howell, 144 Ponce de Leon Ave. N. E., Atlanta, Ga.
Secretary: Dr. Lester A. Brown, 478 Peachtree St. N. E., Atlanta, Ga.
Place: Grady Hospital. Time: 6:00 p. m., second Wednesday of each month from October to May.

BALTIMORE MEDICAL SOCIETY, SECTION ON OPHTHALMOLOGY

Chairman: Dr. Ernst Bodenheimer, 1212 Eutaw Pl., Baltimore.
Secretary: Dr. Thomas R. O'Rourk, 104 W. Madison St., Baltimore.
Place: Medical and Chirurgical Faculty, 1211 Cathedral St. Time: 8:30 p. m., fourth Thursday of each month from October to March.

Birmingham Eye, Ear, Nose and Throat Club

President: Each member, in alphabetical order.
Secretary: Dr. Luther Wilson, Woodward Bldg., Birmingham, Ala.
Place: Tutwiler Hotel. Time: 6:30 p. m., second Tuesday of each month, September to May, inclusive.

Brooklyn Ophthalmological Society

President: Dr. Maurice Wieselthier, 1322 Union St., Brooklyn.
Secretary-Treasurer: Dr. Harold F. Schilback, 142 Joralemon St., Brooklyn.
Place: Kings County Medical Society Bldg., 1313 Bedford Ave. Time: Third Thursday in February, April, May, October and December.

Buffalo Ophthalmologic Club

President: Dr. James G. Fowler, 412 Linwood Ave., Buffalo.
Secretary-Treasurer: Dr. Sheldon B. Freeman, 196 Linwood Ave., Buffalo.
Time: Second Thursday of each month.

Chattanooga Society of Ophthalmology and Otolaryngology

President: Each member, in alphabetical order.
Secretary: Dr. Douglas Chamberlain, Chattanooga Bank Bldg., Chattanooga, Tenn.
Place: Mountain City Club. Time: Second Thursday of each month from September to May.

Chicago Ophthalmological Society

President: Dr. Richard Gamble, 30 N. Michigan Ave., Chicago.
Secretary-Treasurer: Dr. Vernon M. Leech, 55 E. Washington St., Chicago.
Place: Chicago Towers Club, 505 N. Michigan Ave. Time: Third Monday of each month from October to May.

Cincinnati Ophthalmic Club

Chairman: Each member, in rotation.
Secretary-Treasurer: Dr. E. R. Thomas, 819 Carew Tower, Cincinnati.
Place: Holmes Memorial Library, Cincinnati General Hospital. Time: 8:15 p. m., third Monday of each month except June, July and August.

Cleveland Ophthalmologic Club

Chairman: Dr. Albert D. Ruedemann, Cleveland Clinic, Cleveland.
Secretary: Dr. B. J. Wolpaw, 2323 Prospect Ave., Cleveland.
Time: Second Tuesday in October, December, February and April.

College of Physicians, Philadelphia, Section on Ophthalmology

Chairman: Dr. Francis H. Adler, 313 S. 17th St., Philadelphia.
Clerk: Dr. W. S. Reese, 1901 Walnut St., Philadelphia.
Time: Third Thursday of every month from October to April, inclusive.

Columbus Ophthalmological and Oto-Laryngological Society

Chairman: Dr. C. D. Postle, 240 E. State St., Columbus, Ohio.
Secretary-Treasurer: Dr. Hugh C. Thompson, 289 E. State St., Columbus, Ohio.
Place: The Neil House. Time: 6 p. m., first Monday of each month.

Corpus Christi Eye, Ear, Nose and Throat Society

Chairman: Dr. F. K. Stroud, 416 Chaparral St., Corpus Christi, Texas.
Secretary: Dr. Arthur Padilla, 414 Medical Professional Bldg., Corpus Christi, Texas.
Time: Second Friday of each month from October to May.

Dallas Academy of Ophthalmology and Oto-Laryngology

President: Dr. Dan Brannin, Medical Arts Bldg., Dallas, Texas.
Secretary: Dr. L. E. Darrough, 4105 Live Oak St., Dallas, Texas.
Place: Dallas Athletic Club. Time: 6:30 p. m., first Tuesday of each month from October to June. The November, January and March meetings are devoted to clinical work.

Des Moines Academy of Ophthalmology and Otolaryngology

President: Dr. H. C. Schmitz, 604 Locust St., Des Moines, Iowa.
Secretary-Treasurer: Dr. Byron M. Merkel, 604 Locust St., Des Moines, Iowa.
Time: 7:45 p. m., third Monday of every month from September to May.

Detroit Ophthalmological Club

Chairman: Members rotate alphabetically.
Secretary: Dr. Arthur S. Hale, 1609 Eaton Tower, Detroit.
Time: 6:30 p. m., first Wednesday of each month.

Detroit Ophthalmological Society

President: Dr. Parker Heath, 1553 Woodward Ave., Detroit.
Secretary: Dr. Leland F. Carter, 1553 Woodward Ave., Detroit.
Place: Club rooms of Wayne County Medical Society. Time: Third Thursday of each month from November to April, inclusive.

Eastern New York Eye, Ear, Nose and Throat Association

President: Dr. L. A. Hulsebosch, 191 Glen St., Glen Falls.
Secretary-Treasurer: Dr. Joseph L. Holohan, 330 State St., Albany.
Time: Third Wednesday in October, November, March, April, May and June.

Fort Worth Eye, Ear, Nose and Throat Society

President: Dr. W. R. Thompson, 602 W. 10th St., Fort Worth, Texas.
Secretary-Treasurer: Dr. A. E. Jackson, 602 W. 10th St., Fort Worth, Texas.
Place: Medical Hall, Medical Arts Bldg. Time: 7:30 p. m., first Friday of each month except July and August.

Houston Academy of Medicine, Eye, Ear, Nose and Throat Section

President: Dr. J. Charles Dickson, 1617 Medical Arts Bldg., Houston, Texas.
Secretary: Dr. William J. Snow, 708 Medical Arts Bldg., Houston, Texas.
Place: Medical Arts Bldg., Harris County Medical Society Rooms. Time: 8 p. m., second Thursday of each month from September to June.

Indianapolis Ophthalmological and Otolaryngological Society

President: Dr. J. M. Masters, 23 E. Ohio St., Indianapolis.
Secretary: Dr. Kenneth L. Craft, 23 E. Ohio St., Indianapolis.
Place: Indianapolis Athletic Club. Time: 6:30 p. m., second Thursday of each month from November to May.

Kansas City Society of Ophthalmology and Oto-Laryngology

President: Dr. Homer Beal, 1103 Grand Ave., Kansas City, Mo.
Secretary: Dr. Desmond Curran, Federal Reserve Bank Bldg., Kansas City, Mo.
Time: Third Thursday of each month from October to June. The November, January and March meetings are devoted to clinical work.

Long Beach Eye, Ear, Nose and Throat Society

Chairman: Dr. Paul Southgate, 117 E. 8th St., Long Beach, Calif.
Secretary-Treasurer: Dr. Kirt G. Parks, 605 Professional Bldg., Long Beach, Calif.
Place: Professional Bldg. Time: Last Wednesday of each month from October to May.

Los Angeles Society of Ophthalmology and Otolaryngology

President: Dr. John P. Lordan, 2007 Wilshire Blvd., Los Angeles.
Secretary-Treasurer: Dr. Colby Hall, 1136 W. 6th St., Los Angeles.
Place: Los Angeles County Medical Association Bldg., 1925 Wilshire Blvd. Time: 6:00 p. m., fourth Monday of each month from September to May, inclusive.

Louisville Eye and Ear Society

President: Dr. Joseph S. Heitger, Heyburn Bldg., Louisville, Ky.
Secretary-Treasurer: Dr. J. W. Fish, 321 W. Broadway, Louisville, Ky.
Place: Brown Hotel. Time: 6:30 p. m., second Thursday of each month from September to May, inclusive.

Medical Society of the District of Columbia, Section of Ophthalmology and Otolaryngology

Chairman: Dr. E. J. Cummings, 1835 I St. N. W., Washington.
Secretary: Dr. P. S. Constantinople, 1835 I St. N. W., Washington.
Place: 1718 M St. N. W. Time: 8 p. m., third Friday of each month from October to April, inclusive.

Memphis Society of Ophthalmology and Otolaryngology

Chairman: Each member, in alphabetical order.
Secretary: Dr. Sam H. Sanders, 1089 Madison Ave., Memphis, Tenn.
Place: Eye Clinic of Memphis Eye, Ear, Nose and Throat Hospital. Time: 8 p. m., second Tuesday of each month from September to May.

Milwaukee Oto-Ophthalmic Society

President: Dr. John B. Hitz, 411 E. Mason St., Milwaukee.
Secretary-Treasurer: Dr. Ralph T. Rank, 238 W. Wisconsin Ave., Milwaukee.
Place: University Club. Time: 6:30 p. m., second Tuesday of each month.

Montgomery County Medical Society

Chairman: Dr. H. V. Dutrow, 1040 Fidelity Medical Bldg., Dayton, Ohio.
Secretary-Treasurer: Dr. Maitland D. Place, 981 Reibold Bldg., Dayton, Ohio.
Place: Van Cleve Hotel. Time: 6:30 p. m., first Tuesday of each month from October to June, inclusive.

Montreal Ophthalmological Society

President: Dr. J. Rosenbaum, 1396 Ste. Catherine St. W., Montreal, Canada.
Secretary: Dr. L. Tessier, 1230 St. Joseph Blvd. E., Montreal, Canada.
Time: Second Thursday of October, December, February and April.

Nashville Academy of Ophthalmology and Otolaryngology

Chairman: Dr. Andrew Hollabaugh, Doctors Bldg., Nashville, Tenn.
Secretary: Dr. Guy Maness, Medical Arts Bldg., Nashville, Tenn.
Place: St. Thomas Hospital. Time: 8 p. m., third Monday of each month from October to May.

New Haven Ophthalmological Society

President: Dr. Leonard C. Whiting, 121 Whitney Ave., New Haven, Conn.
Secretary: Dr. Frederick A. Wies, 255 Bradley St., New Haven, Conn.

NEW ORLEANS OPHTHALMOLOGICAL AND OTOLARYNGOLOGICAL SOCIETY

President: Dr. W. B. Clark, 1012 American Bank Bldg., New Orleans.
Secretary: Dr. Mercer G. Lynch, 1018 Maison Blanche Bldg., New Orleans.
Place: Louisiana State University Medical Bldg. Time: 8 p. m., second Tuesday of each month from October to May.

NEW YORK ACADEMY OF MEDICINE, SECTION OF OPHTHALMOLOGY

Chairman: Dr. Algernon Reese, 73 E. 71st St., New York.
Secretary: Dr. Brittain Payne, 35 E. 70th St., New York.
Time: 8:30 p. m., third Monday of every month from October to May, inclusive.

NEW YORK SOCIETY FOR CLINICAL OPHTHALMOLOGY

President: Dr. Arthur M. Yudkin, 257 Church St., New Haven, Conn.
Secretary: Dr. Benjamin Esterman, 515 Park Ave., New York.
Place: Squibb Hall, 745–5th Ave. Time: 8 p. m., first Monday of each month from October to May, inclusive.

OKLAHOMA CITY ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. R. E. Leatherock, Cushing, Okla.
Secretary: Dr. Harry C. Ford, 1014 Medical Arts Bldg., Oklahoma City.
Place: University Hospital. Time: Second Tuesday of each month from September to May.

OMAHA AND COUNCIL BLUFFS OPHTHALMOLOGICAL AND OTO-LARYNGOLOGICAL SOCIETY

President: Dr. W. Howard Heine, 635 N. Main St., Fremont, Neb.
Secretary-Treasurer: Dr. W. Howard Morrison, 1500 Medical Arts Bldg., Omaha.
Place: Omaha Club, 20th and Douglas Sts., Omaha. Time: 6 p. m., dinner; 7 p. m., program; third Wednesday of each month from October to May.

PASSAIC-BERGEN OPHTHALMOLOGICAL CLUB

President: Dr. R. N. Berke, 430 Union St., Hackensack, N. J.
Secretary-Treasurer: Dr. T. A. Sanfacon, 340 Park Ave., Paterson, N. J.
Place: Paterson Eye and Ear Infirmary. Time: 9 p. m., last Friday of every month, except June, July and August.

PHILADELPHIA COUNTY MEDICAL SOCIETY, EYE SECTION

Chairman: Dr. Walter I. Lillie, 255 S. 17th St., Philadelphia.
Secretary: Dr. Edmund B. Spaeth, 1930 Chestnut St., Philadelphia.
Time: First Thursday of each month from October to May.

PITTSBURGH OPHTHALMOLOGICAL SOCIETY

President: Dr. Edward A. Weisser, 119–5th Ave., Pittsburgh.
Secretary: Dr. George H. Shuman, 351–5th Ave., Pittsburgh.
Place: Pittsburgh Academy of Medicine Bldg. Time: Fourth Monday of each month, except June, July, August and September.

RICHMOND OPHTHALMOLOGICAL AND OTO-LARYNGOLOGICAL SOCIETY

President: Dr. W. F. Bryce, Medical Arts Bldg., Richmond, Va.
Secretary: Dr. Richard W. Vaughan, Medical Arts Bldg., Richmond, Va.
Place: Westmoreland Club. Time: 6 p. m., second Monday of each month from October to May.

ROCHESTER EYE, EAR, NOSE AND THROAT SOCIETY

President: Dr. Edwin S. Ingersoll, 26 S. Goodman St., Rochester, N. Y.
Secretary-Treasurer: Dr. Charles T. Sullivan, 277 Alexander St., Rochester, N. Y.
Place: Rochester Academy of Medicine, 1441 East Ave. Time: 8 p. m., second Wednesday of each month from September to May.

St. Louis Ophthalmic Society

President: Dr. J. F. Hardesty, Missouri Theatre Bldg., St. Louis.
Secretary: Dr. Carl C. Beisbarth, 3720 Washington Blvd., St. Louis.
Place: Oscar Johnson Institute. Time: Clinical meeting 5:30 p. m., dinner and scientific meeting 6:30 p. m., fourth Friday of each month from October to April, inclusive, except December.

San Antonio Ophthalmolo-Oto-Laryngological Society

President: Dr. Dan Russell, 705 E. Houston St., San Antonio, Texas.
Secretary-Treasurer: Dr. P. G. Bowen, 315 Camden St., San Antonio, Texas.
Place: Bexar County Medical Library. Time: 8 p. m., first Tuesday of each month from October to May.

San Francisco County Medical Society, Section on Eye, Ear, Nose and Throat

Chairman: Dr. Matthew Hosmer, 384 Post St., San Francisco.
Secretary: Dr. Fred Boyle, 490 Post St., San Francisco.
Place: Society's Bldg., 2180 Washington St., San Francisco. Time: Fourth Tuesday of every month except June, July and December.

Shreveport Eye, Ear, Nose and Throat Society

President: Dr. David C. Swearingen, Slattery Bldg., Shreveport, La.
Secretary-Treasurer: Dr. Kenneth Jones, Medical Arts Bldg., Shreveport, La.
Place: Shreveport Charity Hospital. Time: 7:30 p. m., first Monday of every month except July, August and September.

Spokane Academy of Ophthalmology and Oto-Laryngology

President: Dr. L. A. Parsell, 421 Riverside Ave., Spokane, Wash.
Secretary: Dr. Robert L. Pohl, 407 Riverside Ave., Spokane, Wash.
Place: Paulsen Medical and Dental Library. Time: 8 p. m., fourth Tuesday of each month except June, July and August.

Syracuse Eye, Ear, Nose and Throat Society

President: Dr. F. R. Webster, State Tower Bldg., Syracuse, N. Y.
Secretary-Treasurer: Dr. John R. Myers, State Tower Bldg., Syracuse, N. Y.
Place: University Club. Time: First Tuesday of each month except June, July and August.

Toledo Eye, Ear, Nose and Throat Society

Chairman: Dr. S. H. Patterson, 1251–15th St., Toledo, Ohio.
Secretary: Dr. J. E. Minns, 316 Michigan St., Toledo, Ohio.
Place: Toledo Club. Time: Each month except June, July and August.

Toronto Academy of Medicine, Section of Ophthalmology

Chairman: Dr. W. R. F. Luke, 316 Medical Arts Bldg., Toronto, Canada.
Secretary: Dr. W. T. Gratton, 216 Medical Arts Bldg., Toronto, Canada.
Place: Academy of Medicine, 13 Queens Park. Time: First Monday of each month, November to April.

Washington, D. C., Ophthalmological Society

President: Dr. Frank Costenbader, 1726 I St. N. W., Washington, D. C.
Secretary-Treasurer: Dr. L. Conner Moss, 1710 Rhode Island Ave. N.W., Washington, D. C.
Place: Episcopal Eye and Ear Hospital. Time: 7:30 p. m., first Monday in November, January, March and April.

Wilkes-Barre Ophthalmological Society

Chairman: Each member in turn.
Secretary: Dr. Samuel T. Buckman, 70 S. Franklin St., Wilkes-Barre, Pa.
Place: Office of chairman. Time: Last Tuesday of each month from October to May.